UNFOLDING DIAGRAMS AS GENERATIVE DESIGN TOOLS IN ARCHITECTURAL DESIGN PROCESS: UNITED NETWORK (UN) STUDIO-MÖBIUS HOUSE / ARNHEM CENTRAL STATION / MERCEDES BENZ MUSEUM

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ABSTRACT

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The aim of this thesis is to explore the role of the diagrams as generative design tools in architectural design process. Identifying the utilization of the diagrams as infrastructural and organizational elements in the design process, it aims to be concentrate on their potency for generating novel design concepts. The search has been for the possibilities of design processes developed and manipulated not through analytical use of diagrams that represents the already established relationships but through their generative use that is responsible for the proliferation of ideas for novel design concepts. The alteration in the definition of diagrams, their active role in the generation of design ideas, and their progression during the design process, as well as the ways in which they contribute to the delay of formal concerns through the practice are scrutinized.

In order to explore the generative and mediating roles of diagrams in architectural design practice, this thesis examines the utilization of diagrams by exemplifying the strategies of UN Studio. Through exploration of their pioneering projects, the

Möbius House, the Arnhem Central Station and the Mercedes Benz Museum, it aims to unfold their design methods regarding diagrams.

Diagrams are examined in terms of the way they are utilized and operated from conceptualization to building. While standing at a critical distance, it argues for an architectural design process where design ideas are formed and evolved by utilization of diagrams as generative tools from the initial phases of the design to the actualization of the building.

Keywords: diagram, generative design tools, design process, UN Studio, Möbius House, Arnhem Central Station, Mercedes-Benz Museum.

ÖZ

MİMARİ TASARIM SÜREÇLERİNDE ÜRETKEN TASARIM ARAÇLARI OLARAK DİYAGRAMLARIN ÇÖZÜMLENMESİ: UN STUDIO'NUN MÖBIUS EVİ, ARNHEM MERKEZ İSTASYONU MERCEDES BENZ MÜZESİ PROJELERİ

Kuyumcu, Başak

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Bu tezin amacı diyagramların üretken tasarım araçları olarak mimari tasarım sürecindeki rollerinin araştırılmasıdır. Diyagramların tasarım sürecinde yapısal ve organizasyona yönelik kurgulanma biçimlerini inceleyerek, onların yeni tasarım fikirlerini üretmekteki potansiyellerine odaklanılır. Tezin amacıyla ilintili olarak, diyagramların tanımlanmış ilişkileri açığa çıkartan açıklayıcı tasarım araçları olarak değil, tasarım süreçlerine ait yeni anlayışların ve kavramların üretilmesini tetikleyen üretici tasarım araçları olarak kullanılması ve geliştirilmesinin tasarım sürecine getireceği olanaklılıklar araştırılır. Diyagramların tasarım sürecinde tanımlanmasına ait değişim, tasarım anlayışlarını geliştirmekteki üretken rolleri ve bu rollerini tasarım süreci boyunca devam ettirmeleri, bunların yanı sıra sonuç ürün ve biçime ait kaygıları ertelemekteki katkıları incelenir.

Diyagramların mimari tasarım pratiği için üretici ve aracı olma rollerini tartışan bu tez, UN Studio'nun tasarım süreçlerinde diagramı kullanma biçimlerini ele alarak konuyu inceler. Bu kullanımları Möbius Evi, Arnhem Merkez İstasyonu ve

Mercedes Benz Müzesi projeleri üzerinden tartışırken, aynı zamanda UN Studio'nun diyagram merkezli tasarım metotlarının çözümlenmesi amaçlanır.

Diyagramların yeni tasarım fikirlerinin üretilmesindeki rolleriyle tasarım süreçlerinde nasıl işledikleri ve bu süreci nasıl yönlendirdikleri açıklanmaya çalışılır. Tasarım fikirlerinin başlangıçtan sonuç ürüne kadar diyagramların kullanımıyla üretildiği, şekillendiği ve evrildiği bir mimari tasarım sürecini eleştirel bir bakış açısıyla tartışır.

Anahtar kelimeler: diyagram, üretken tasarım araçları, tasarım süreci, UN Studio, Möbius Evi, Arnhem Merkez İstasyonu, Mercedes Benz Müzesi.

To My Parents Reyhan and Necati Kuyumcu

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CHAPTER 1

INTRODUCTION

As tools for thinking, problem solving, abstraction and communication, diagrams aid to render relations, forces, and concepts. Thus, they have a considerably wide range of applications and procedures in several disciplines, as well as in architecture. Besides their utilization as representational images for identification of a design idea, as statistical and schematic images, and as reductive tools for the compression of information, architectural diagrams are also used as generative tools for engendering alternative possibilities and suggesting proliferation of ideas. The use of diagrams as generative design tools triggers a shift in the architectural design process suggesting a departure from formal concerns to concerns for the process. This departure has led to new definitions that rely mostly on topological and non-linear generative design processes rather than the typological, linear and formal ones. The use of diagrams as generative design tools starts to suggest alternative possibilities in the process of designing by focusing on the instrumentalization of generative relationships rather than formal representations of explanatory ideas.

1.1 Aim

This thesis aims at exploring the role of the diagrams as generative design tools in architectural design process. The adjective “generative” is used in this thesis as a modifier to release diagram from its schematic and statistical meanings. It is aimed to indicate the shift from the use of the diagram as a “reductive tool” known as the

compression of information in its conventional meaning. “Generative” is not used as a notion that implies a “production method” in the design process. Instead, it directly focuses on the generation of the architectural design process and the way how the diagram informs and is transformed in that process. It implies a generation of novel relationships and qualities and promotes to trigger novel directions and meanings for the design phases. The notion of “generative” is borrowed from the idea of “proliferating machine” that UN Studio defines as the “diagram” in the design process. Emphasizing the transformation of the conventional significance of the diagram, UN Studio uses this term to imply the way how today’s architecture interprets the diagram by advances in computational design tools introduced.[1] In this thesis “generative” used as a notion that pursues and evokes a proliferating and instrumentalising function.

By identifying the utilization of the diagrams as infrastructural and organizational elements in the design process, the thesis aims to concentrate on their potency for generating novel design concepts. The evolution of the diagrams as creative mediators in the generative design process is attempted to be observed. The way of utilization and operation of the diagrams from conceptualization to building is underlined. Starting with the distinction of the use of diagrams in the design process made by Peter Eisenman as 1.) Explanatory-analytic, and as 2.) generative,[2] diagrams as generative design tools are tried to be explored through an investigation of the design processes of UN Studio where diagrams are utilized as “proliferating machines.”[3]

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[1] Ben Van Berkel and Caroline Bos, “Diagrams, Interactive Instruments in Operation.” *Any Magazine,* No. 23 (1998): 20.

[2] Ibid, 27.

[3] Ibid, 20.

1.2 Objective

The transformed use of diagrams has increased diagrammatic architectural practices that regard the diagram as a generative tool. Defining their design practices as being "diagrammatic" from conceptualization to building, the founders of UN Studio, Ben van Berkel and Caroline Bos, concentrate on constructing a diagrammatic practice that "pursues a proliferating, generating and open instrumentalization in architecture."[4] In order to explore generative and mediator roles of diagrams in architectural design practice, this thesis examines the utilization of diagrams by UN Studio in their design practices.

While trying to identify UN Studio's design strategy regarding the use of diagrams, this thesis also intends to investigate the role of the diagrams as mediators throughout the design process. As an external element "in between the object and the subject that is used to introduce other themes and organizations into a project," the diagrams can be claimed as mediators that structure the design process from concept to realization.[5] Since they function as mediators, diagrams delineate the transformation of forces and relations of the organizations. The diagram, defining the apparent or possible relations besides embedding condensed information, is a tool that triggers a generative design process and proliferates design ideas. Inheriting the potential to generate, it provides for the transformation of these relations. Exemplifying the strategies of UN Studio regarding the use of diagrams through their practice, it is aimed to unfold the role of the diagrams as creative mediators in the generative design process.

There are two reasons why UN Studio was selected for such an investigation. Firstly, it is UN Studio's precise approach to the discourse of diagrams in the

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[4] Ibid.

[5] Ben van Berkel, "Interview," *Domus* 852 (October 2002): 101.

development of new architectural design tools. Utilizing and advancing the diagrammatic design practice from the conceptualization of design ideas to their development, representation and manufacture make the Studio's design practices relevant. Ben van Berkel and Caroline Bos define their design strategy as being a "diagrammatic practice."[6] Their elaborate description of the design approach could help to identify evolution and utilization of diagrams through their practice.

Secondly, the plenty of publications that they have published and that have been issued on their work is significant for gathering the required information on UN Studio. Rather than making an over-interpretation of interpretations in the journals, books or essays that have been issued, thanks to the books and interviews they have published, this investigation has been based on the information obtained from reasonable and convenient sources. The availability and accessibility of the documents where their design processes are elaborated precisely by their own publications provide a direct examination to unfold their design process.

Examining the evolution of diagrams and defining their roles as generative design tools and mediators throughout the architectural design process, this thesis seeks answers to: What is the role of diagrams as generative design tools? In what ways they alter and inform architectural design?

1.3. Method of Study

The stated aim of the thesis is tried to be achieved through examination of the diagrammatic practices of UN Studio. To achieve a more comprehensive understanding of the mediating role of diagrams as generative tools in architectural design, this thesis presents an analysis of the design processes of the UN Studio.

[6] Ben Van Berkel and Caroline Bos, *Move-Tecniques*, Vol.2 (Amsterdam: UN Studio & Goose Press, 1999), 19.

Besides being an exploration of their pioneering projects, the Möbius House, the Arnhem Central Station and the Mercedes Benz Museum, it is also an exploration and illustration of their design methods regarding diagrams.

There are three criteria for the selection of these three projects for the aim of this thesis. First criterion is that they are relevant projects to emphasize utilization and evolution of the diagrams as generative design tools. It is thought that the projects could be illustrate the way how generation of design ideas from conceptualization to their representation and realization is triggered and informed by the use of diagrams as generative design tools for the aim of this thesis.

The second criterion is the different qualities of the projects and differences in their design processes. They are differentiated from each other in terms of their building years, programs, and scales. The first study is from early 1990's (1993-1998), second is from mid-1990's (1996-1998) and the last is from the early 2000's (2001-2006). The time period that they were built coincide with the design ideas and experiments of UN Studio on diagrammatic architecture and with their publications where these projects were elaborated. Each study (a house, an urban masterplan, and a museum) has a different scale. The diversity of scale enables to examine the use of diagrams as generative design tools in operation that acts for the generation of different design processes with different qualities and scales.

Finally, the projects were selected due to their methods of formation generated by the diagrams. The diagrams that structure these projects are variants of each other. They can also be manipulated and applied in different ways. They can be transformed for different projects and transferred from one project to another. Namely, the Möbius Strip, its three dimensional variant the Klein bottle, and the trefoil diagram are variations of the same mathematical model that could be utilized in different ways and for different design processes: in Möbius House, in Arnhem Central Station and in Mercedes Benz Museum. This multi-utilization aspect of the

diagrams shows their potency to operate for generation of new design concepts and processes. The diagram, which is kept operative, experimental and open to development, helps to open up novel generative relationships during the architectural design process.[7]

Moreover, besides the use of selective literature related to the philosophical and theoretical accounts and limited to those published by UN Studio, an interview with Ben van Berkel conducted by the author has been made use of in writing this thesis.

1.4 Context of the Study

The revival of interest in contemporary practices on the role of the diagrams dominating the architectural discourse since mid-90's widely originated from the shift of attention from explanatory aspects of diagrams to their generative potency. In the last decade of the 20th century, an interdisciplinary field and research community emerged focusing on the idea of the diagram in conjunction with introduction of computational design approaches. This community consists of researchers and practitioners from many divergent fields as cognitive science, psychology, linguistics, visual programming, data visualization, graphic design, education, history and architecture.[8] While the consideration of ideas on diagrams increased the number of the symposiums, conferences, and workshops since the beginning of the 1990s, they have increased as well under the umbrella of curiosity regarding diagram's potentials.[9]

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[7] Ben van Berkel (UN Studio-Amsterdam), interview with Ben van Berkel conducted by the author of this thesis, September 2009. See Appendix A.

[8] Alan F. Blackwell and Yuri Enelhardt, "A Taxonomy of Diagram Taxonomies," in *Proceedings of Thinking with Diagrams 98: Is There a Science of Diagrams?*(1998): 60-70.

[9] TVL 96: International Workshop on Theory of Visula Languages In conjunction with AVI 96 (May 30, 1996, Gubbio, Italy); TVL 97: International Workshop on Theory of Visual Languages In conjunction with VL 97 (September 27, 1997, Capri, Italy); DRII: Reasoning with Diagrammatic

The curiosity about diagrams also affected the architectural community. A theoretical and practical architectural discourse emerged with the rise of the interest in the idea of diagrams. Some architectural periodicals dedicated special issues on the diagram, such as the *ANY Magazine*, *Daidalos*, *Architectural Review* and *OASE*.[10] Thus, in addition to the dedication of the issues of the periodicals to the subject, individual contributions from the architectural field emerged such as those by Peter Eisenman, William Braham, Stan Allen, Robert E. Somol, Anthony Vidler, Ben van Berkel, Greg Lynn, Mark Wigley, Manuel De Landa, Pia Ednie-Brown, Kenneth Knoespel, Birger Sevaldson, Ellen Yi-Luen Do and Mark Gross.

Despite the premise of unification lying under the contributions made on diagrams, the contemporary theoretical and professional architectural production related to the subject displays a significantly wide range of scope and content. Thus, the diversity and multiplicity of the uses of diagram define the boundaries of a problematic field which, according to Vidler, involves "a wide range of approaches and styles that at first glance seem entirely disparate – from diagrammatic caricature to theoretical discourse, modernist revival to digital experiment."[11]

These contributions also triggered Master's and Ph.D theses on diagrammatic approaches in architectural design process. To illustrate, thesis by Hyungmin Pai,

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Representations II 1997 AAAI Fall Symposium (November 8-10, 1997, Cambridge, Massachussets, USA); tWd98: Thinking with Diagrams 98 (August 22-23, 1998, Aberystwyth, UK); Diagrams 2000: 1st International Conference on the Theory and Application of Diagrams (September 1-3, 2000, Edinburgh, Scotland, UK); Diagrams 2002: 2nd International Conference on the Theory and Application of Diagrams (April 18-20, 2002, Callaway Gardens, Georgia, USA); eCAADe Education in Computer Aided Architectural Design in Europe (Weimar, Deutschland, 2000); Diagrams 2004: 3rd International Conference on the Theory and Application of Diagrams (March 22-24, 2004, Cambridge, UK); also CAAD Futures 2009 Conference will be held in Montreal will focus on design methodology and discuss the latest innovations in CAD technology.

[10] ANY Magazine (no.23 1998), Daidalos(no 74 2000), Architectural Review(no.1307 2006) and OASE(no.48 1999) are the periodicals which have dedicated issues on "diagram."

[11] Anthony Vidler, "Diagrams of Diagrams: Architectural Abstraction and Modern Representation," *Representations* 72 (Fall 2000): 18.

Fehmi Doğan, Paul Frederick Emmons, Nihat Kalfazade, Birger Ragnvald Sevaldson, Alper Küçük, Baran Yardımcı, and Engin Maçoro issue the diagrams mainly as a design tool, each handling it in different manners.[12]

The aim of Hyungmin Pai's thesis, which was also published as a book in 2002, is to examine the discourse of architecture in America from the late nineteenth century to mid twentieth.[13] The transformation witnessed in architecture and in the practices of architects is indicated by the shift from the use of portfolio, which was a collection of plans and elevations of accepted historical types until the late nineteenth century as the basis for architectural design, to the dominance of the functional diagram. With the rise of scientific and empirical approaches in the delivery of buildings, construction and engineering industries have fallen into conflict with the traditional typological purposes of the portfolio paradigm. According to Pai, in late 1930's this transformation led to the displacement of the portfolio by the diagram. Presenting an overview of the discourses on diagrams in late 1930s, Pai demonstrates the later adoption of diagrams such as circulation diagrams, efficiency studies, and bubble diagrams in architecture transforming the idea and nature of plan layouts.

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[12] These theses were chosen due to the significant relevance of their subject to the present study. Hyungmin Pai, "From the portfolio to the diagram: Architectural discourse and the transformation of the discipline of architecture in America, 1918-1943" (Ph.D. Dissertation, Massachusetts Institute of Technology, 1993); Fehmi Doğan, "The role of conceptual diagrams in the architectural design process: Case studies of the First Unitarian Church by Louis Kahn, the Staatsgalerie by Stirling and Wilford Associates, and the Jewish Museum by Daniel Libeskind" (Ph.D. Dissertation, Georgia Institute of Technology, 2003); Paul Frederick Emmons, "The Image of Function: Architectural Diagrams in Handbooks and Normative Practices in the Twentieth Century" (Ph.D. Dissertation, University of Pennsylvania, 2003); Nihat Kalfazade, "Diagrammatic Potency of the "Nine Square Grid" in Architectural Design," (Master Thesis, METU, 2004); Birger Sevaldson, Developing Digital DesignTechniques.Investigations on Creative Design Computing, (Ph.D. Dissertation, Oslo School of Architecture, 2005); Alper Küçük, "The Architectural Precedent and the Diagram : A Comparative Analysis of Le Corbusier's Villa Savoye and Rem Koolhasss' Maison a Bordeaux" (Master Thesis, METU, 2007); Baran Yardımcı, "Diagram as an Architectural Design Tool"(Master Thesis, ITU, 2007); Engin N. Maçoro, "Diagrams as a Tool for Creative Process in Architectural Design," (Master Thesis, ITU, 2009).

[13] Hyungmin Pai, *The Portfolio and the Diagram: Architecture, Discourse, and Modernity in America* (Cambridge, Mass: MIT Press, 2002).

In his thesis, Fehmi Doğan investigates the roles of the conceptual diagrams in the initial phases of the design process by presenting three different cases: Unitarian Church by Louis Kahn, the Staatsgalerie by Stirling and Wilford Associates, and the Jewish Museum by Daniel Libeskind. He questions the early phases of design and the role of conceptual diagrams in facilitating explorations in design. Introducing the nature of the initial phases of design, he introduces ways to work at these phases. Indicating the significance of the role of conceptual diagrams, Doğan explores their evolution in the architectural design processes of the three projects selected. Archival research, interviews, and evaluation of documents on these three projects have led Doğan to draw conclusions about a "dual exploration", "problem space" and "solution space," mediated by conceptual diagrams in the architectural design process.

The thesis by Emmons asserts that diagrams are not abstract facts but physical images. The thesis explores the diagrams in multiple contexts to better understand the power and formation of functional diagrams and examines hidden meanings of pre-modern diagrams.

Exploring the diagrammatic potency of the "nine-square grid" in architectural design, Nihat Kalfazade asserts that the nine square grid as a diagram has a potential to generate different spatial relations. The thesis describes the use of nine-square grid as a design tool for ordering the program, structure and the context in architectural design with references to selected projects.

Sevaldson claims that abstraction of diagrams is better suited for the exploitation of digital creativity than types, metaphors and symbols. It is asserted in the thesis that diagrams are the tools of abstraction which help to establish working definitions in design contexts and to conceptualize "the diagrammatic." Implying that the generative diagrams work as "possibility triggers" in the design process, his thesis

emphasizes the "generative diagrams" as tools which both describe and generate responses to the social and cultural forces in an urban context.

Alper Küçük underlines diagram's role as a mnemonic tool in architectural design. To achieve a better understanding of the mediating role of diagrams, in order to highlight the relation between architectural precedents and diagrams, his study presents a comparative analysis of Le Corbusier's Villa Savoye and Rem Koolhaas's Maison á Bordeaux.

Baran Yardımcı's thesis concentrates on the issue of transforming the knowledge within the design process. It is asserted in the thesis that diagrams are a part of "internal manifestations" of architecture as design tools that render graphical transformation. The purpose of the study is to investigate the varying applications of diagrams as generative system tools and to explore their future potentials and application techniques.

Lastly, the thesis written by Engin Maçoro emphasizes the theoretical background and the role of the diagrams as tools for creative process in architectural design by considering the diagrams as a dynamic tool for expressivity, abstraction and creativity. The thesis seeks the definitions of diagram as visual tools, as design tools and as dynamic tools for creative process.

To conclude, the curiosity on diagrammatic issues dominates the architectural discourse theoretically and practically. All these recent contributions on the discourse of diagrams include important inquiries. This thesis is aware of the majority of such issues on diagrams. A major inquiry of the present study is intended to be on the transformation of the notion of diagram in practice. However, the thesis will differentiate itself by focusing on the shifted role of the diagrams transformed in the design process for generating new possibilities. In order to do this, this study intends to be an individual contribution on the role of diagrams as

generative design tools by elaborating the ways in which UN Studio instrumentalize them in their work. The significance of the recent interpretations of diagrams will be acknowledged while remaining at a critical distance in observing the current discussions.

1.5 Structure of the Thesis

The following chapter aims to extend the literature review on diagrams and focuses on diagrams as generative design tools and their mediating role throughout the design process by referring to several design processes of UN Studio. Acting as a bridge between the theoretical framework and the main study of the thesis, the second chapter intends to put forward an evaluation of diagrams in the design process; it examines how they are constructed, embedded, manipulated and dissolved through the actualization of the final outcome. Discussed in the contemporary discourses together with the introduction of computational design tools, the use of diagrams as generative design tools is tried to be related to the context of the new techniques employed in the design world. The chapter starts with the context of novel design strategies where the evolution of diagrams as generative design tools is supported by the computational design environment. While following an examination on how diagrams as generative design tools find their place in the design process, the meaning and the role of the diagrams are discussed in the manner which is both conceptually and instrumentally associated with the Deleuzian discourse. With reconsideration of generative design strategies triggered by the altered role of the diagrams from analytical to generative, it is intended to explore new definitions of diagrams that trigger a tendency to topological and non-linear relationships in the design process. The potential of diagrams for generating alternative possibilities in the process of designing is tried to be achieved by focusing on the instrumentalization of the relationships rather than formal representations of explanatory ideas.

The third, fourth and fifth chapters present projects by UN Studio in which the generative roles of the diagrams are explored in architectural practice. By providing an examination of the structure of the diagram used and its potency for the related project, the ways they alter and inform the design process are indicated. General contextual and programmatic information about the projects are supplied, and the integration of the diagram with the analysis and studies derived from these contextual and programmatic inputs is pointed out. At which stage the diagram is integrated with the design process and how, as a proliferative mediator, it triggers new ideas throughout the realization of the building are explored.

The final chapter, which is the conclusion part of the thesis, discusses the role of diagrams as generative design tools depending on the findings of the thesis. While standing at a critical distance, it argues for an architectural design process where the generative design ideas are formed, generated and evolved by the diagrams from the initial phases of the design to the actualization of the building.

CHAPTER 2

RECONSIDERATION OF DIAGRAMS AS GENERATIVE DESIGN TOOLS IN THE DESIGN STRATEGIES OF UN STUDIO

UN Studio, the generative and mediating role of diagrams in their design practices from conceptualization to building, and their precise approach to the discourse of diagrams concerning the developments of new architectural design tools will be examined in this chapter. While Ben van Berkel and Caroline Bos define their process of design as being a "diagrammatic practice," the utilization and evolution of the diagrams as a generative and creative design tools are going to be analyzed and observed. [14] This chapter will provide an exploration of the integration and operation of the diagrams as generative design tools in the architectural design process of UN Studio.

General information on UN Studio's design strategies is followed by the shift in the use of diagrams from being analytical to being generative design tools. The departure from typological to topological practices in design process with this shift and the introduction of computational design tools are elaborated. UN Studio's interpretation of Deleuze's introduction of "abstract machines" into the architectural design process is examined to provide a definition of the diagram, a reason why it is used, and a conceptual organization for the selection, insertion, and interpretation of the diagrams as generative design tools. Finally, the potency of the diagrams for

[14] See Ben Van Berkel and Caroline Bos, *Move*, Vol.2, Amsterdam: UN Studio & Goose Press, 1999. UN Studio explains their design practice as being diagrammatic.

generating novel design ideas and for structuring the whole design process is questioned in reference to the architectural design methodologies of UN Studio.

2.1 Structure of the UN Studio

UN Studio, which stands for "United Network," is an international design office which was first founded in 1988 as "van Berkel & Bos Architectuurbureau" in Amsterdam. United Network Studio name was given to the office in 1998 in order to indicate the corporate system of the office. Collaboration between architects, graphic designers and constructors, building consultants, photographers, stylists and media designers form the organization of design strategies in the studio. The use of "innovative materials, integrated design principles, and close collaboration" is the key principle of the studio which comprises architecture, urban development and infrastructure network. Indicating the design process of a project as a continuous loop, the Studio employs different collaborates from other disciplines in different phases of the project (Figure 1). This network organization is comprised of internal teams such as Design Team, Management Team, Co-ordination Team, and Technology Team. Introducing novel elements to their internal organization aids to develop a new working method, "a network practice."[15]

Co-founder of the studio, Ben van Berkel, who was graduated from Architectural Association in London, taught also there, in Columbia University, in Berlage Institute, and in UCLA; he has been a visiting lecturer at Princeton University, and he is currently professor of Conceptual Design and head of the architecture department at the Staedelschule in Frankfurt am Main, Germany. Caroline Bos, who is also a visiting lecturer at Princeton University and has taught at the Berlage Institute, and UCLA, is the other co-founder. As an art historian she has been

[15] Ben van Berkel and Caroline Bos, *Move-Effects*, Vol.3 (UN Studio & Goose Press, 1999), 254.

involved in UN Studio projects as an analyst. Her observations on different programmatic issues have become integral with different projects conducted in the studio. [16]

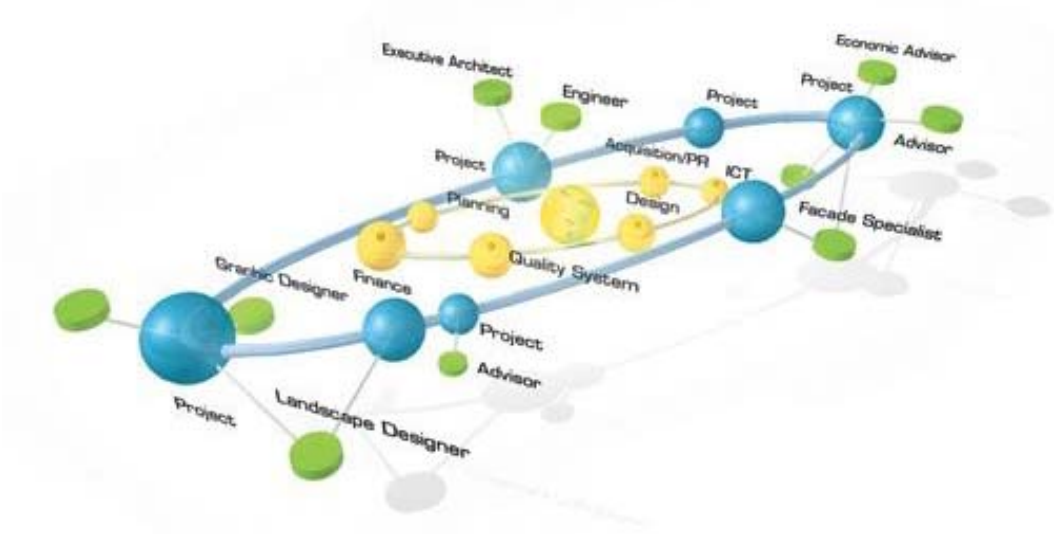

Figure 1: Structure of Corporation System in United Network Studio

UN Studio, http://www.unstudio.com/ (last accessed in July 2010).

2.2. Diagrams as Generative Design Tools

To achieve a comprehensive understanding of the mediating role of diagrams as generative tools in their architectural design process, UN Studio has introduced various publications on their design strategies.

Among these publications "*Mobile Forces-Mobile Krafte*" 1995, "*Move-Techniques*," 1999, in Volume 2 and the "*Design Models*" 2006 issued the diagram-based architectural design processes of UN Studio.[17] In the *Move-Techniques*, which

[16] UN Studio, http://www.unstudio.com/nl/unstudio/studio/people/ben-berkel (last accessed in May 2010).

[17] *Move-Techniques* is the second volume of the *Move* series which have three volumes issued on the UN Studio's design strategies with several projects. This second volume which - is dedicated to the

is featured as an extended version of the *Mobile Forces book*, diagrams are indicated as a technique which generates instrumental meanings as a mediator in the design and production of architecture. UN Studio uses the "diagrammatic technique" "to allow the architectural imagination to find relevance in contemporary circumstances-and to communicate its policy." Indicating the "technique" as distinct from production methods, van Berkel defines it as instrumental in shaping the concept. [18]

While defined as a technique, which functions as a base study, the diagram is used as a mediator that generates design ideas throughout the process. Specifying the diagrammatic technique that promotes a "proliferating, generating and instrumentalising approach to design" van Berkel introduces it as presenting "an opportunity to examine the social-discursive aspect of architectural practice from within."[19]

Although van Berkel acknowledges the diagrams being as old as architecture itself, he interprets them as distinct from their being understood as reductive tools for compression of information. By indicating the novel roles of the diagrams in architectural design practice, Ben van Berkel states that:

> The specific meaning of the diagrams in relation to architecture has been colored by our knowledge of Bauhaus methods. But let's forget about this; as a quick glance at the diagrammatic practices of Gropius, Mies van der Rohe, and their students makes clear. To see architecture as a built line diagram is practically the reverse of our position.[20]

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diagrams that are used as generative design tools and trigger novel design ideas, provides several projects that illustrate the use of diagrams in their design process.

[18] Ben van Berkel and Caroline Bos, *Move-Imagination*, Vol.1 (UN Studio & Goose Press, 1999), 17.

[19]Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation." *Any Magazine,* No. 23 (1998): 20.

[20] Ibid.

Thus, rather than using the diagram as a statistical, schematic or a conceptual image, van Berkel interprets the diagram as a "proliferating machine" that transforms the conventional meaning of the diagram.[21]

2.2.1. The Use of Diagrams: From Analytical to Generative Design Tools

Peter Eisenman provides a definition of diagrams which is used as a starting point of this thesis and classifies the role of the diagram in the design process. Eisenman introduces the use of diagrams in architectural practice as "explanatory or analytical devices" and as "generative devices."[22] The distinction between these two uses of diagrams stem from their potentials in construction of new relationships. Already constructed relationships are represented in using the diagrams as analytical devices. The analytical use of diagrams aids to understand structural principles of existing systems and situations. On the other hand, used generatively, diagrams represent the forces and relations in order to define a generative design process.

In order to emphasize the generative role of the diagrams in design processes, it is consciously avoided to call them as "generative diagrams."[23] Regarding the aim of this thesis it is not tried to be identified a new type of diagram. Instead, it is intentionally focused on a new quality of the role of diagrams in the design process by transforming the diagram's conventional significance.

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[21] Ibid.

[22] Peter Eisenman, "Diagram: An Original Scene of Writing." *Any Magazine,* No.23 (1998): 27.

[23] Birger Sevaldson used the notion "generative diagrams" that generated from a process where the input parameters and the set up are prepared in advance with referring a process which consist in parametric design languages. Birger Sevalson, "Developing Digital Design Tecniques: Investigations on Creative Design Computing" (Ph.D. Dissertation, Oslo School of Architecture, 2005); Birger Sevalson, "Dynamic Generative Diagrams" in eCAADe, (Weimar, 2000); Birger Sevaldson, "Research on Digital Design Strategies," (Oslo School of Architecture, 1999).

Diagrams as generative design tools aid to generate possible structural, organizational and formal principles on a generic level. As opposed to conventional modes of analytical diagram, referring to generative use of diagrams Eisenman states that:

> […] unlike traditional forms of representation, as a generator a diagram is a mediation between a palpable object, a real building, and what can be called architecture's interiority. Clearly this generative role is different from the diagram in other discourses […] where the diagram may reveal latent structures but does not explain how those structures generate other sentences or equations.[24]

In the analytical use of diagrams, which is the most common use of diagrams in the history of diagrammatic practices, function and form relationship is the aim of the design process. The functional use of diagrams which ends up with the most appropriate form of the conceptual ideas aims to define requirements and functions. Rudolf Wittkower's introduction of the "nine-square grid" to describe Palladian villas and Christopher Alexander's "Constructive Diagrams" are instances of diagram based studies which aim to rationalize the formal solutions for the conditions described through the analytical use of diagrams.

In the analytical use of diagrams which is different form a sketch or a plan of the building, the diagram attempts to uncover the structure of the already constructed relationships, such as Wittkower's nine-square grid (Figure 2). Even though the nine-square grid is not a conventional structure itself, it reveals diagrams of the spatial organizations in the design process.[25] Therefore, the analytical use of

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[24] Peter Eisenman, "Diagram: An Original Scene of Writing." *Any Magazine,* No.23 (1998): 27.

[25] Nihat Kalfazade, Diagrammatic Potency of the Nine Square Grid in Architectural Design, Department of Architecture (Master Thesis, Middle East Technical University, 2004), 13.

For further information on Pallodio's Villas: Rudolf Wittkower, "Principle of Palladio's Architecture, Palladio's Geometry: The Villas." *Architectural Principles in the Age of Humanism* (New York: Random House, 1965), 70-76 and Greg Lynn, "Multiplicitous and Inorganic Bodies", *Assemblage,* No:19(1992): 32-49.

diagrams tends to explore the latent information related with form, structure and program.

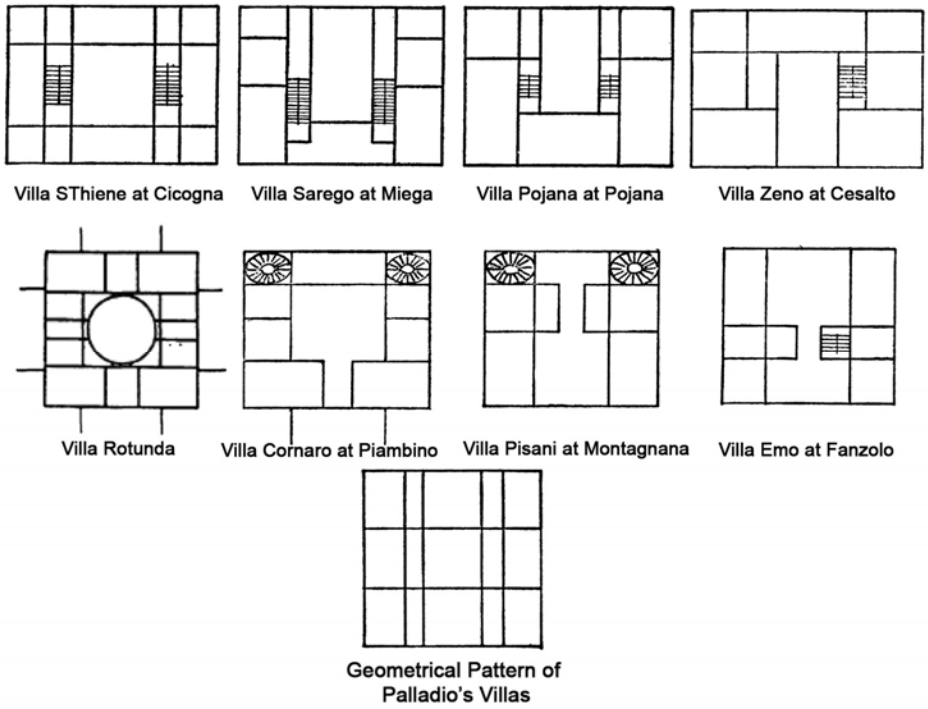

Figure 2: Schematized Plans of Palladio's Villas and their Geometrical Pattern

Rudolf Wittkower, "Principles of Palladio's Architecture" *Journal of the Warburg and Courtauld Institutes*, Vol. 7 (1944), 102-122.

This aim of the use of diagram analytically is found also in the interpretation of Christopher Alexander's diagrams. The strategy of Alexander relied on identifying problems and requirements in order to release the most appropriate and effective final solution for the design process. Defining the diagram as a "pattern" which is identified as an abstraction of a real situation, and "conveys the physical influence of certain demands or forces," Christopher Alexander characterizes design as matching program requirements with corresponding diagram.[26] The diagram is the "starting

[26] Christopher Alexander, *Notes on the Synthesis of Form* (Harvard University Press, 1964), 85.

point of synthesis." In his examples of diagrams he mentions the stroboscopic photograph of milk drop splash - a diagram of impact; Le Corbusier's Ville Radieuse - a diagram revealing the physical consequences of the requirements of high density and the demand for sun and air; and a sphere - a diagram of maximum volume with minimum skin.[27]

The diagrams, in the manner used by Alexander, represent sizes and approximations, and structure assemblages for various activities by highlighting certain relationships.[28] According to Alexander, diagrams can summarize formal characteristics or functional properties; however "constructive diagrams" provide a bridge between requirements and form (Figure 3). Emphasizing this duality of diagrams, with form and requirement relationships, for him, the constructive diagram can describe the form by offering "a way of searching for form" therefore the "[constructive diagram] is the most important tool in the process of design."[29]

Figure 3: Constructive Diagram by Christopher Alexander

Christopher Alexander, *Notes on the Synthesis of Form* (Harvard University Press, October 24, 1964), 88.

Also see Christopher Alexander, *The Timeless Way of Building* (New York: Oxford University Press, 1979) and *A Pattern Language: Towns, Buildings, Construction* (New York: Oxford University Press, 1977).

[27] Christopher Alexander, *Notes on the Synthesis of Form* (Harvard University Press, 1964), 85.

[28] Ellen Yi-Luen Do and Mark Gross, "Thinking With Diagrams in Architectural Design," University of Washington, http://depts.washington.edu/ redline1/AIRE264.pdf.
(last accessed in December 2005).

[29] Christopher Alexander, *Notes on the Synthesis of Form* (Harvard University Press, 1964), 92.

The diagram illustrated above presents information on the traffic flow requirements for a traffic interchange in condensed graphic form. Alexander discusses the example of a traffic-flow map at a junction in which the thickness of the traffic-flow arrows translates into the width of the required traffic lanes and states that:

> In this form the diagram indicates directly what form the new intersection must take. Clearly a thick arrow requires a wide street, so that the overall pattern called for emerges directly from the diagram. It is both a requirements diagram and a form diagram. This diagram is a constructive one. [30]

Alexander's method is structured so as to notice and identify problems in order to describe the most effective solution and therefore formalize the process.[31] In order to find the most appropriate functional organization, the so called analytical diagrams are directly converted and finalized with a formal outcome.

Used as generative design tools, however, diagrams describe the potential relationships, distinct from material reality and fall apart from the analytical use of diagrams in that they do not suggest direct formal or relational implications. Since they are abstractions away from materiality, they function as instrumental devices that proliferate design ideas and trigger to focus on the design process rather than concentrating on the formal outcome. [32]

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[30] Christopher Alexander, *Notes on the Synthesis of Form* (Harvard University Press, 1964), 88.

[31] Christopher Alexander, *A Pattern Language: Towns, Buildings, Construction* (New York: Oxford University Press, 1979).

[32] The notion of diagram as an analytical and generative tool has been pointed out also by Birger Sevaldson in his thesis and in his published essays. By referring the Peter Eisenman's definition of diagrams as analytical devices and generative devices, he defines the diagrams for the purpose of his argument as descriptive diagrams and generative diagrams.
Birger Sevalson, "Dynamic Generative Diagrams" in eCAADe, (Weimar, 2000).

Defining the diagram as a "proliferating machine," UN Studio marks its current disjunction from analytical and conventional uses and states the significance of the use of diagram as a generative design tool for the architectural design process as follows:

> For architecture, the diagram conveys an unspoken essence, disconnected from an ideal or an ideology that is random, intuitive, subjective, not bound to a linear logic that can be physical, structural, spatial, or technical. [33]

The diagram, defining the apparent or possible relations besides embedding condensed information, is a device that triggers a generative design process and proliferates design ideas. The process provides the generation of continuous design phases and translations to built form. A generative design process can be defined by the generative ideas, which are embedded in the structure of the design phases, through the identification of the relations rather than the identification of the finalized form. Through the use of diagrams as generative design tools a generative design process is defined with forces and relations being represented and overlapped. Since they function as mediators, diagrams delineate the transformation of these forces and relations.

Accordingly, rather than the attention being placed on form, a process oriented design strategy enables the permanent evolution of design ideas throughout the design process. Potentials of creativity offered by the use of diagrams as generative design tools enable shift of attention to the process and provides the relations integrated to the diagram and responding to all phases of the process from concept to realization.

Since the diagram proposes the mediation between relations and their concrete reflection on form, the delay of formal expression leads to generative design

[33] Ben van Berkel and Caroline Bos, *Move-Techniques*, Vol.2 (UN Studio & Goose Press, 1999), 19.

process, where attention is placed on the relations and forces breeding the diagram. The diagram, defining the apparent or possible relations besides embedding condensed information, is a device that triggers a generative design process and proliferates design ideas.[34]

Therefore, embedding condensed information via diagrams into design, constructing possible relationships network triggers a generative design process. Through the generative use of diagrams the information not only codes the relations but also decodes them into the material form of realization. The information embedded in the diagram provides a proliferative and suggestive design process freed form typological concerns of the conventional architectural practices with the mediating role of the diagram between virtual and the real. Diagrams as generative design tools participate throughout the design process and direct the process through their ability to construct the relationships. Ben van Berkel distinguishes the generative use of diagrams from their analytical use which ends up with typological fixations and depends on formal concerns:

> An instrumentalizing technique such as the diagram delays typological fixation. An experimental or instrumental technique does not proceed as literally from signs. If aspects such as routing, time, and organization are incorporated into the structure using an instrumentalizing technique, concepts external to architecture are introduced into it rather than superimposed. Instances of specific interpretation, utilization, perception, construction and so on unfold and proliferate applications on various levels of abstraction, liberating the design from a tendency toward fixed typologies.[35]

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[34] Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation," *Any Magazine,* No.23 (1998): 20.

[35] Ibid, 21.

Compared with the analytical diagrammatic practices, diagrams as generative design tools construct relations and forces in order to define a dynamic design process and escape from the direct translation of the diagram into a formal visualization. Diagrams as generative design tools propose the mediation between concept and the buildings. They are not used only as tools which contribute to the representation of design ideas but as devices defining the whole process, from the conceptualization of design ideas to their development, representation and manufacture. This emphasis on production of the process, rather than coming up with the formal outcome at once, aids to define dynamic and process-oriented design strategies. These strategies provide the designer an open-ended interface to operate which freed from formal determinism of the conventional design approach, initiates a conscious delay in the typological fixation of form and visual representation.

2.2.2. From Typology to Topology

Recent diagrammatic practices in architecture witness a drastic shift from the analytical to the generative. The analytical practice of the diagram, which used to end up with the definition of the most appropriate form, is now being replaced with a diagram does not end up in a fixed solution. Thus, the transformed use of diagrams in the last two decades has multiplied diagrammatic architectural practices regarding the diagram as an inspirational and generative tool.

Although the use of diagrams as generative design tools dominates the contemporary architectural discourse within the last two decades, the history of diagrammatic practices witnesses their most common use as analytical devices, with the attention placed on type. In such analytical use of the diagram, the aim is to cover the most appropriate formal definition for the identified specific function. William Braham highlighting the correlation of form and function states that:

> Since the late eighteenth century, building typology has provided the dominant model of an architectural working method, even though architects have rarely been able to maintain any kind of useful distinction between typologies of function (the museum, church or house) and typologies of form (the pyramid, atrium, or basilica).[36]

In the architectural working methods depending on the formal conventions that fix the relation between form and function, diagrams used as analytically end up with fixed typologies. Attention is placed on the type rather than on generative multiple instances of the analyzed situations.

Also defined as a "working method" by Braham, diagrams, in their analytical use, function to conclude formal solutions in a rational way, dependent on the formal conventions of the designer's habits of perception, as well as the cultures and appropriate forms of practice.[37] In such analytical reasoning, one formal solution is dictated for the specified function, instead of generating multiple instances of the analyzed situation.

To avoid early formal or "typological fixation"[38] in the design process, diagrams as generative design tools enable the generation of diverse variations with the aid of computational design tools, since it inhibits the dictation of the formal outcome of identified relations. Through diagrams, the designer does not only code the relations and forces or decodes them into material form, but also proposes a generative process detached from "pre-existing typologies": Van Berkel and Bos, making

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[36] William Braham, "After Typology: The Suffering of Diagrams." *AD: Contemporary Processes in Architecture.* Academy Editions: London, Vol. 70, No. 3 (2000): 9.

[37] Ibid, 10.

[38] Ben van Berkel and Caroline Bos use this phrase in order to criticize the approach rely on formal qualities rather than relations in design process. Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation," *Any Magazine,* No.23 (1998): 23.

extensive use of diagrams in their architectural practice, define them as mediators of the design process and state that:

> We see it (the diagram) as an external element, in between the object and the subject that we use to introduce other themes and organizations into a project with the aim of escaping from pre-existing typologies.[39]

Van Berkel and Bos indicate that the use of diagrams as generative tools, opposed to their use as analytical tools, prevents typological fixation.[40] They indicate the use of diagrams as instrumental technique, which delays the typological fixation consciously, as opposed to their use as representational technique. Thus, a generative design process can be defined via generative diagrammatic practices which are released from formal concerns and material reality. By emphasizing a generative design process that refer to the use of diagrams as an instrumental technique beyond mere representation, van Berkel states that:

> Diagrammatic practice delays the relentless intrusion of signs, thereby allowing architecture to articulate an alternative to a representational design technique. A representational technique implies that we converge on reality from a conceptual position and in that way fix the relationship between idea and form, between content and structure. When form and content are superimposed in this way, a type emerges. This is the problem with an architecture that is based on a representational concept; it can not escape existing typologies.[41]

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[39] Ben van Berkel, "Interview," *Domus* 852 (October 2002): 101.

[40] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 40.

[41] Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation," *Any Magazine,* No.23 (1998): 21.

Utilization of diagrams as generative design tools marks the departure from typological practice. This focus on the generative character of diagrams then opens up the grounds for topological practices. Attention shifts to the oscillation between the generative process for defining relations and the formal outcome. The attention placed on relations rather than form offers a generative design process where the typological practice gives way to a topological one.

2.2.2.1. Topological Tendency in the Generative Architectural Design Process

Topology as a branch of geometry or modern mathematics inspires architecture as an operative tool and a conceptual source.[42] Topological studies focus on the transformation of the quantitative properties of geometric forms without affecting their qualitative properties.[43] Identified as "rubber sheet geometry," the potential of the transformation of a form is projected.[44]

A topological tendency is experienced within architecture as a result of advances in mathematics and geometry. Architectural design process and its tools are rearranged due to the advances in the environment of mathematics and geometry with the introduction of computational design tools. Since the Euclidean geometry and conventional design tools in the experimentation of form are substituted with the non-Euclidian, more dynamic geometries in space and form making process, architectural design tools and processes introduced a novel approach in the

[42] Guiseppa Di Cristina, "The Topological Tendency in Architecture," *Science and Architecture*. Ed. Guiseppa Di Cristina (Wiley Academy, 2001), 6-13.

[43] I.M. James, *History of Topology* (Amsterdam, New York, 1999).

[44] The transformation of topological study also called as rubber-sheet geometry which means that any figure drawn on a rubber sheet and stretched is topologically unchanged. A topological transformation simulates the transformation of the rubber sheet thus includes stretching, curving, folding or twisting, where the relations between the parts of the figure are preserved. Can be found more information in George K. Francis, *A Topological Picturebook* (Springer, October 24, 2006) and I.M. James, *History of Topology* (Amsterdam, New York, 1999).

definition of theory and practice of architecture.[45] This new design environment not only triggers the creativity of the designers, who contribute to develop complex design ideas, but also reforms the design process and the architectural design tools with which the designer experiences new techniques and explores new media. The tools introduced with these advances provide a departure from the conventional design tools to more dynamic and complex ones and their more sophisticated outcomes.

The outcomes of the shifts in mathematics and geometry have triggered novel definitions of form-making process which relies on mathematical relations rather than directly on the form itself. Since topological studies concern the transformation of the quantitative properties of geometric forms without affecting their qualitative properties, topological studies in the architectural design provide a flexible design approach to designers and challenge the form generation processes through continuous transformations with mathematical relations. The use of computational design tools defined by the mathematical equations and proportions aids generative design ideas and dynamic transformations of topological studies become a part of novel design processes.

It can be asserted that topological studies and computational design tools share a common base informing the architectural design process. The topological studies provide the designer with the potential to define complex forms with continuous transformation enabled by computational design tools and concepts. Especially in the parametric design approach, topological studies have a critical significance. With the computational design approaches in which the form is defined parametrically topological transformations can be manipulated with the parameters. Using the parameters that are related to each other helps to produce open-ended relationships which enable modifications and redefinitions thus freeing the expression of form

[45] See more information in Harold Scott Macdonald Coxeter, *Non-Euclidean Geometry* (Washington, D.C., Mathematical Association of America, 1998).

from non-relative and fixed definitions. Through the parametric model defined the designer finds the way to describe complex forms with topological transformations. Thus, it may be said that with the topological tendency in architecture the design process can be re-arranged, re-formed and re-defined with the aid of ideas that depend on topological transformations.

Topological structures in which topological transformations are re-related create design ideas, since their dynamic transformation represents the continuous evolution of form, thus the evolution of the design concept that depends on the aspects generating it.[46] Released from the formal concerns, topological structures such as the Möbius Strip, the Klein bottle, the Trefoil Knot, which will be discussed in relation with the three projects studied, inherit the potential to challenge the conception of architectural design process.

Beside aiding to define a dynamic, generative architectural design process, topological structures trigger the evolution of design ideas depending on relations and interactions throughout the design process. Thus, the evolution of the design ideas from concept to building in the design process gains a great importance and can be realized with the introduction of topological studies in architectural design.

UN Studio has been using the topological structures as inspiring tools in order to develop a generative, dynamic and a non-linear design process. Dynamic transformation of the topologically inspired diagrams with the defined topological relations has been affecting their design processes. Indicating the instrumentalized aspect of the topological diagrams in the design process van Berkel states:

[46] Guiseppa Di Cristina "The Topological Tendency in Architecture," *Science and Architecture*, Ed. Guiseppa Di Cristina (Wiley Academy, 2001), 6-13.

> Topologically inspired diagrams like the spring structure, Seifert Surface, Möbius band and Klein Bottle are not applied to architecture in a stringent mathematical way, but they are not mere metaphors or themes either. These orientable and non-orientable organizations provide unifying, abstract, three-dimensional models that can be wholly or partially projected onto real-life locations to integrate the imagination and the policy at the basis of the projects and its programmes, with techniques, organization and public utility. They provide direction and introduce into architecture the concept-ualization of differential space and time.[47]

The introduction of the topological structures as generative tools for designing guided the spatial transformation of the process into a whole through the conceptual implementation of the diagram. The definition of conditions of topological surfaces as orientable and non-orientable forms aid to identify the surface studies of the design.[48] The transformability of topological surfaces results in non-orientable objects. Van Berkel states the generative aspect of these topological forms of structures and indicates that "architectural interpretation of these mathematical notions is diagrammatic that is to say, organizational, generative and proliferating"[49] (Figure 4).

The master plan studies of Arnhem Central Station project by UN Studio is an example of the introduction of the topological diagram into the design process. After developing the organization to a certain level with the analysis of the context and the program, a necessity for an optimal model emerges in order to combine these

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[47] Ben van Berkel and Caroline Bos, *Move*, Vol. 3 (UN Studio & Goose Press, 1999), 21.

[48] Mathematically orientability means that a surface has two distinct sides, thus, pertains to a spatially obvious situation. Non-orientability describes a hybrid surface condition in which the two sides are warped. Ben van Berkel and Caroline Bos, *Move*, Vol.3 (UN Studio & Goose Press, 1999), 250.

[49] Ben van Berkel and Caroline Bos, *Move*, Vol.3 (UN Studio & Goose Press, 1999), 250.

values.[50] Emergence of the "knot of planes" idea triggers the conceptual implementation of the non-orientable "Klein Bottle" diagram into the design process where it guided the spatial, structural and technical interpretation[51] (Figure 5). The generative potential of the diagram provided for prolific design ideas and defining a generative design process.

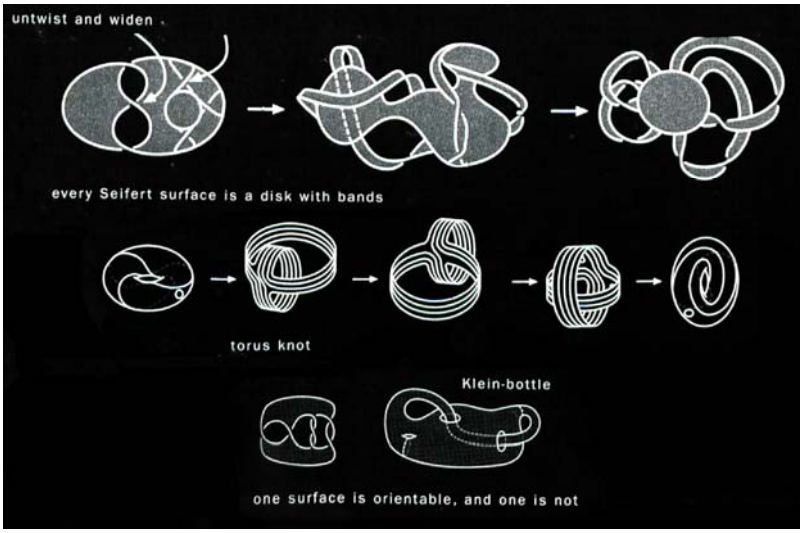

Figure 4: Topological Knot and Seifert Surface Studies of UN Studio.
Ben van Berkel and Caroline Bos, *Move-Techniques*, Vol.3 (UN Studio & Goose Press, 1999), 14.

Figure 5 (left): Klein Bottle Diagram, (right) The Topological Transformation of the Klein Bottle Diagram as an infrastructural element for the master plan of Arnhem Central Station.

Aaron Betsky, *UN Studio-The Floating Space* (Taschen, 2007), 12.

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[50] Gregg Lynn and Daniel Birnbaum, "Digital Conversation" in *UN Studio UN Fold* (Rotterdam: Nai Publishers, 2002), 17.

[51] A precise examination on the Klein Bottle diagram and Arnhem Central Station project will be conducted in the fourth chapter of the thesis. Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation" *Any Magazine,* No. 23 (1998): 22.

2.2.3. Introduction of Computational Design Tools

Topology, in architecture, implies the dynamic variation of form and inspires the tendency to topological forms which is facilitated by the developments in computer aided design tools. Due to this tendency it is possible to speak about topological forms and their possible outcomes within both theoretical and practical discourse of architecture.

With the introduction of computational design tools into the design environment, a generative design process is defined via generative design tools which provide a process for creating and maintaining the sophisticated models of diagram studies. The computational tools such as the software used and the visual programming languages provide compatible design strategies to work through complex diagrams. Thus, those tools introduced via computational design programs facilitate to work with multiple layers of the information by providing the modification and interaction with each other.

With the introduction of computational design tools, the use of diagram in the architectural design process also witnesses a shift in terms of the dynamism of the process. The process, altered from static to dynamic, triggers the shift from linear to non-linear design process and leads to focus on relations which are identified via computational tools rather than early representation of form. The design tools are diversified with the construction of interacting relationships.

The association of the computational design tools with the diagrams as generative design tools may have asserted to change the limitations of the conventional design processes in struggle with the complex relations. With the use of diagrams as generative design tools in which information is transferred, interacted and manipulated by defined parameters, the diagram continues to inform design process throughout the process from concept to realization. This ability of mapping

complex relationships and rendering correlation between concept and the final outcome implement the complex and various interpretations of diagrams and their evolution through the final outcome. In other words, it may be asserted that the generative use of diagrams enables the definition and correlation of new relationships, emphasize new references and allows to study with multi-layered information in one order.

The strategies used in computational design approaches, such as parametric design, diagrammatic abstraction, associative geometry, and scripting, are all intended to define the desired complexity and productivity of the process. These strategies, influenced by advances in mathematics and geometry, depend highly on parameters and relations which define the entire process. [52]

UN Studio utilizes the parametric design strategy as a "way of proportioning and structuring digital information."[53] Studying with a parametric model not only enables to define the position of various points in space, but also the relationship between them. In the case of the Mercedes Museum, parameters defined for the whole design process by the introduction of the Trefoil Knot diagram make the manipulation of the identified layers of information for all phases of the design. The "tetrapod" columns, almost none of which are the same, are modeled with parameters in terms of form, slenderness and load transmission[54] (Figure 6). Therefore, any change in the radius of the building or facade properties is defined automatically by the generation of the parameters. Calling this controllable process of construction as "digital sustainability," van Berkel states that:

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[52] Branko Kolarevic "Towards Non-Linearity and Indeterminacy in Design," *Cognition and Computation in Digital Design.* Design Computing Cognition'04.

[53] Ben van Berkel and Caroline Bos, *Move*, Vol.3 (UN Studio & Goose Press, 1999), 250.

[54] Interview with Ben van Berkel "Digital Sustainability and Spaces That Follow You," *Detailtopics* http://detailtopics.com/digital-architecture/en/discussion/interview-ben-van-berkel/ (last accessed July 2010).

> Parameters express architectural values in rational, functional and objective terms. As the evolution of the chosen parameters is traced over time, the project emerges as of its own accords. […] parametric design as a technique nonetheless uncovers the neutral values forming the basis of the project.[55]

This new domain of design enables the operation of the same parametric model that continually evolves with data integration throughout the design and manufacturing processes. Parametric models defined in earlier stages which are based on relations and parameters of the introduced software compatible with all phases of design provide information on manufacturing procedures as well. Through the parametric model defined, it is triggered to describe complex forms under topological transformations.

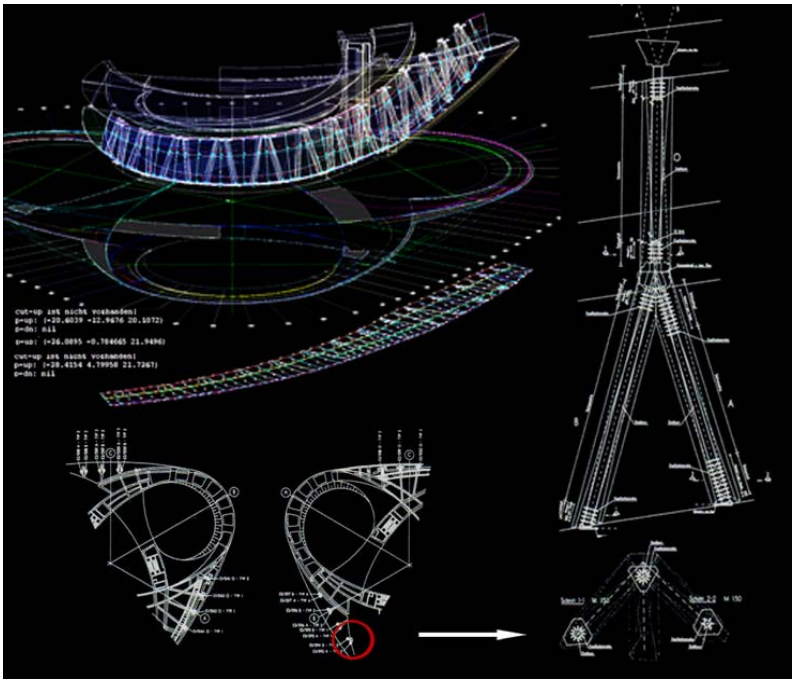

Figure 6: A parametric 3D-model of the whole museum building to coordinate all the subsequent planning steps from design to production.

UN Studio, *Buy me a Mercedes-Benz –The Book of the Museum* (Actar December 2006), 82 and 126.

[55] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 250.

For van Berkel, the most important architectural potentials of the computational design techniques involved in design process are "the expansion of spatial imagination, the radical break with a hierarchical design approach and the introduction of different disciplines into the design process."[56] Ben van Berkel has been using the combinations of digital techniques with computational design tools in the design process of UN Studio since the beginning of the Erasmus Bridge project in 1992.[57] The procedure of designing with the computer-aided design tools is to generate a dynamic, organizational, structural plan with parameter-based techniques. Using the combinations of digital techniques informed by the computational design tools, computational design tools integrate infrastructure and various programs.[58] Indeed, the interactive nature of the computer-aided design aids to proportion and structure the digital information.

The advances provided with the use of computational design tools in the architectural design practice define a departure from the conventional architectural design process. The changes also enable to work with complex situations and forms, since the computational design tools which re-define the architectural design process facilitate defining the complex of relationships for the architect. Computational design tools introduced provide a generative basis for creating and maintaining the sophisticated models of diagram studies. Moreover, the associated use of diagrams and the computational approach enables the definition of new relations, allows multiple interpretations of the information and highlights new reference systems. These tools facilitate the definition of multiple layers besides their modification and interaction with each other. Being generative devices, the flexible possibilities of diagrams delineates the dynamism in the process and inspire

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[56] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 160.

[57] Ben van Berkel and Caroline Bos, "Deep Planning" in *UN Studio UN Fold* (Rotterdam: Nai Publishers, 2002), 38.

[58] Ben van Berkel and Caroline Bos, *L'Architecture d'Aujourd'hui*. No.321 (March 1999): 53.

the creativity of the designer through the multi-layered and modifiable design strategies that are provided by the computational design tools.

2.2.3.1. Studying with Multi-Layered Diagrams

Diagrams associated with computational design tools are structured to respond to the evolution of relations and forces with information integration supplied by analysis in the initial phases of design. The conceptual flow of information adapts itself to the defined conditions of diagrammatic structure and it is included in all layers of the complex diagram in a manageable way. Thus, the designer may have lots of options in order to be able to choose the layers responding to the modification. This generative aspect of the diagrams makes it possible to work easily on all layers of the diagram that are either independent or dependent on each other. The numerous options of relations embedded in the diagram enable to come up with different perspectives and countless solutions in a defined diagrammatic model. Released from the fixations of constant relationships, the flow of information in the diagram triggers a generative construction of the design process.

Represented and managed by the computational design tools, relations and forces take place in the diagrams and design phases in order to make possible their integration and alteration throughout the design process. Owing to this adaptability via diagrams as generative design tools, changes in the relations and forces can be kept under control. Therefore, the coherency between layers of the diagram constructs the design phases and makes possible to generate novel defined relationships throughout the whole design process and to maintain the generative construction of the design process.

Through the multiple layers of diagrams, UN Studio examines diverse situations of relationships and defines existing possibilities in a project. By envisioning multiple

layers of information the diagram also embeds the analysis into phases of design by overlapping the information in a great order. Ben van Berkel defines diagrams as generative design tools which are "packed with information on multi-layers." Therefore, the design process becomes "open to modifications, revisions and progressions" [59] (Figure 7-8).

Figure 7: Multi-Layered Diagram for IFCCA_New York project by UN Studio.

Ben van Berkel and Caroline Bos. *UN Studio UN Fold* (Rotterdam: Nai Publishers, 2002), 55.

[59] Ben van Berkel and Caroline Bos, *Move*, Vol. 2 (UN Studio & Goose Press, 1999), 20.

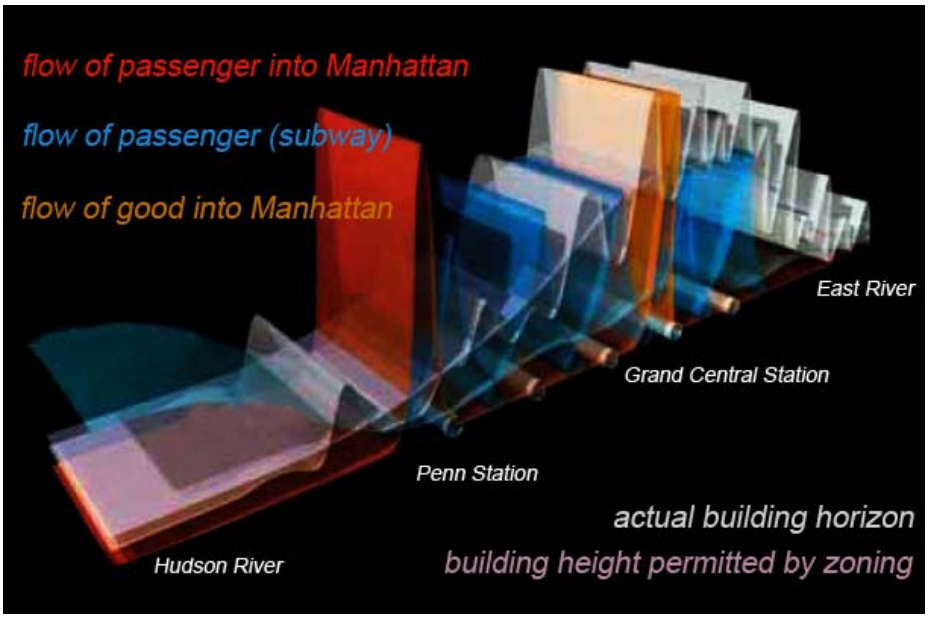

Figure 8: Flow analysis for IFCCA_New York project informed by Multi-Layered diagram.

Ben van Berkel and Caroline Bos. *UN Studio UN Fold* (Rotterdam: Nai Publishers, 2002), 46-47.

Developing the diagram as generative design tool begins with defining its parameters in a multi-layered information system, such as defining the "user categories; in relation to territorial and time-based parameters, and manageable architectural ingredients." The diagrams that UN Studio tends to integrate with their design process trigger the interaction between different actors of analysis supplied by multi-layered information. This relational approach to diagrams generates "new insights into the developmental potential of locations in an integral manner." The movement and orientation analysis can be articulated with the aid of multi-layered diagrams, such as "animated matrix diagram" that illustrates the patterns of a location throughout the days of the week [60] (Figure 9).

[60] Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 16.

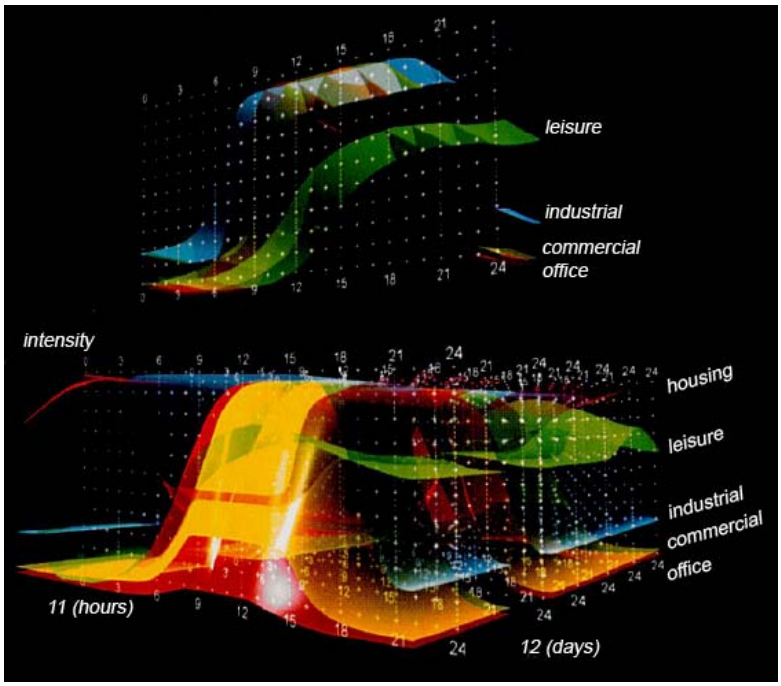

Figure 9: Animated Matrix Diagram that show programmatic activity patterns for IFCCA_New York Project.

Ben van Berkel and Caroline Bos. *UN Studio UN Fold* (Rotterdam: Nai Publishers, 2002), 48-49.

Thus, the design process focused on multi-layered diagrams triggers a generative architectural design process in order to be able to construct novel relations and propose topological relationships in the design process. Defining the multi-layered technique as "Operational Matrix," Ben van Berkel uses it to easily move back and forth between the complex layers of information in the project.[61] The Operational Matrix is used to generate a systematic proposal for the project defined with the diagram and "lists parameters that are obtained with the aid of multi-layered approach"[62] (Figure 10). Thus, the matrix derived from multi-layered representations of analysis aids to define the project as a set of connective potentials of structural, programmatic and topological qualities.[63]

[61] Ben van Berkel and Caroline Bos, *Move*, Vol. 2 (UN Studio & Goose Press, 1999), 160.

[62] Ben van Berkel and Caroline Bos, *Move*, Vol. 3 (UN Studio & Goose Press, 1999), 250.

[63] Ben van Berkel and Caroline Bos, *Move*, Vol. 2 (UN Studio & Goose Press, 1999), 159-167.

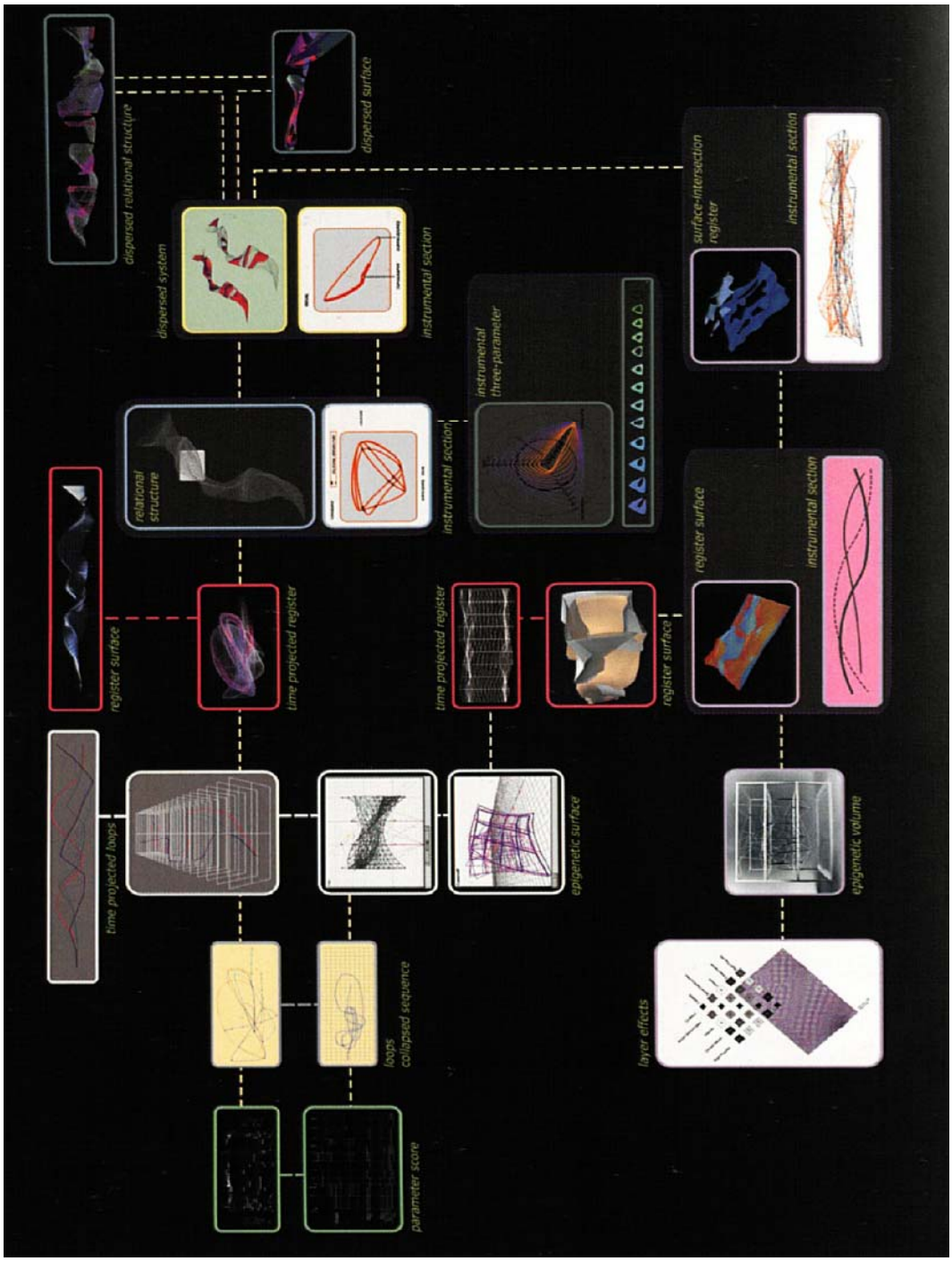

Figure 10: "Operational Matrix" obtained from analysis and multi-layered diagrams.

Ben van Berkel and Caroline Bos, *Move*, Vol. 2 (UN Studio & Goose Press, 1999), 158.

2.2.3.2. Towards a Non-Linear Design Process

The generative design process which is manipulated by the computational design techniques has initiated a creative and non-linear process of form generation, transformation, representation and construction. As a consequence, different phases of the design and manufacturing processes in the act of architectural designing begin to be superpositioned and to be released from strict boundaries between the design phases.

Diagrams constructed by the computational design tools with multi-layered data integration enable to define a dynamic design process which is focused on the relations between the phases of design. New design tools offered by the computational design strategies cause the shifts in the construction of diagrams; diagrams take a part in the design process from initial to latest phases in order to generate the relations between the phases.

Thus, modifying, manipulating and transforming the relations through the diagrams specified at the beginning set up a process in which the boundaries of the phases have a tendency to disappear and put forward a whole and a continuous design process in which the flow of information is provided. Removing the boundaries of phases also provides a non-linear oscillation between the conceptualization of the ideas to realization of the construction. Therefore, this departure from linear to non-linear design process through the generative power of the diagrams contributes to the texture of dynamic design process between concept and realization. Emphasizing the "non-linearity" in generative design process within the context of computational design practice Braham states that:

> In this context, non-linear means that the influences of a particular design situation cannot be simply predicted or characterized, but only experienced or shown as a total

> result, either because the situation is sufficiently dynamic or the influences are too numerous and complex in their interaction.[64]

As in the architectural design processes of UN Studio where diagrams get involved as generative tools, non-linear diagrammatic practices enable the modification of the identified relations between the stages of design via the multi layered construction of the diagram. Therefore, the dynamism of the design process constructed by diagram as a generative design tool is also provided by the non-linearity of the design process by blurring the boundaries between design phases which let the oscillation of relations and forces throughout the design process, from conceptualization to building.

Consequently, it may be asserted that the non-linear design process in the generative diagrammatic practices of UN Studio, which are aided to construct design decisions and relationships, helps to define a dynamic design process influenced by computational design strategies and tools. Therefore, these advances in architectural design process ends up with the shifted use and content of diagram from analytical, static, and linear to generative, dynamic and non-linear one.

2.3. Abstract Machines of UN Studio

In order to be able to examine how the diagram evolved in the architectural design process as a generative tool, van Berkel gives philosophical implications of the diagram as well. By exploring the ways in which the diagram instrumentalizes the concept of organization and its imagery, the determinations of Gilles Deleuze aid to define significant implications of the diagrams in the design process.

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[64] William Braham, "After Typology: The Suffering of Diagrams." *AD: Contemporary Processes in Architecture.* Academy Editions: London, Vol. 70, No. 3 (2000): 11.

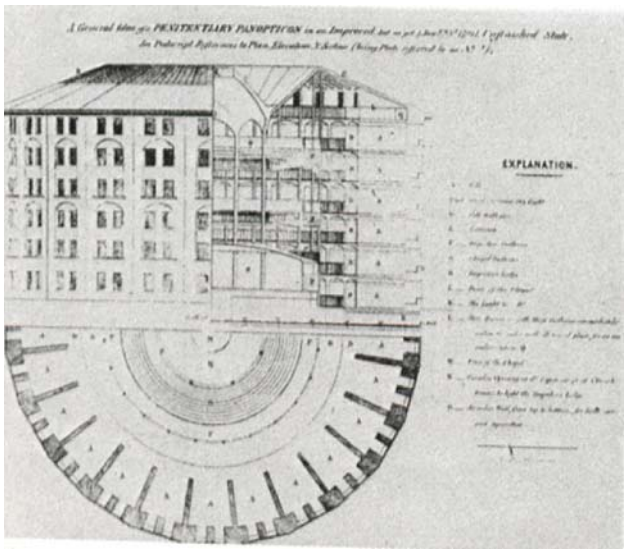
Architecture has been encouraged by the writings of Deleuze who introduced virtual organizations that oscillate between abstract and the real; thus, between ideas and their realizations in the physical world. Ben van Berkel's introduction of Deleuze's ideas into architecture has helped to find answers to significant questions related to their design process: What is diagram?; Why is the diagrams used in design process?; How are diagrams selected, used and interpreted?; How do diagrams become operational?

Indicating that the role of Deleuze's writings must be specifically architectural, van Berkel describes the virtual organization of the diagrams in architectural design process via Deleuze's conceptual readings of Michel Foucault's and Francis Bacon's works. Stating that these readings by Deleuze are significant for understanding diagrams as instrumental tools for a generative design process, van Berkel interprets every reading that reveals a different aspect of the diagram. The aspects interpreted in these readings correspond to different phases of the design process where the selection, application and operation of the diagram are defined.

The first reading by Deleuze, associated with Foucault, identifies the diagram as an "abstract machine" that proliferates novel conditions which are not representational. Interpretation of this reading leads to a virtual organization of the diagram to function as an abstract machine in the design process, and concentrates on the meaning and necessity of the diagram as a generative design tool. Interpretation of the second reading by Deleuze, associated with Francis Bacon's paintings, identifies the diagram as an infrastructural and operational tool for the organization of a generative design process.

In the first reading, Deleuze has pointed out the aspects of what he has called "abstract machine" and what Foucault has called "diagram" starting with Jeremy Bentham's 1785 plan for the Panopticon (Figure 11). For Foucault, who recognized the Panopticon as the diagram of modern power, the plan for the Panopticon is "the

diagram of mechanism of power reduced to its ideal form […] a figure of political technology that may and must be detached from any specific use."[65] Thus, for Foucault, the Panopticon functions as a kind of generalisable model of a function which conveys the spatial organization of a specific form. The Panopticon is an abstraction of a function reduced to its ideal form that involves metaphorical approach to visual representation.



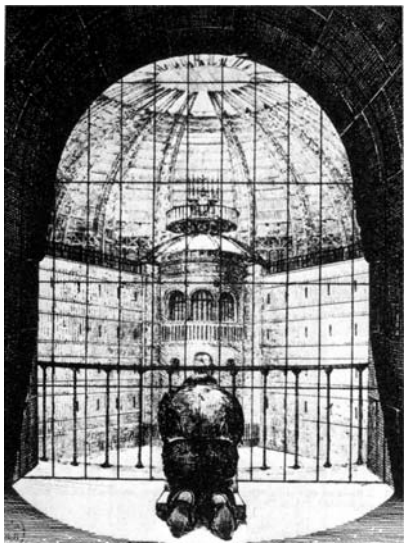


Figure 11: (Left) Panopticon plan of Jeremy Bentham, 1791, (Right) Plan for a Penitentiary, N. Harou-Romain, 1840.

(Left) *John Bowring,* The Works of Jeremy Bentham*, vol. 4 (Edinburgh: William Tait, 1843), 172-173.*

(Right)The prisoner, in his cell, kneeling at prayer before the central inspection tower. Michel Foucault, *Discipline and Punish: The Birth of the Prison* (New York: Vintage Books, 1979), 172.

[65] Michel Foucault, Discipline and Punish: The Birth of the Prison (New York: Vintage Books, 1979), 170.

Although Foucault introduced the notion of "diagram" as an ideal form of specific function and defines the diagram as assemblage of specific situations, techniques and specific function, Deleuze criticizes Foucault for his emphasis on the strategies that form the diagram, rather than its generic aspect which aids proliferation of design ideas. In his book on Foucault, Deleuze calls the diagram as "abstract machine" which superimposes the maps of relations between forces:

> The diagram is functioning, abstracted from any obstacle […] or friction must be detached from any specific use. The diagram is no longer an auditory visual archive but a map, a cartography that is coextensive with the whole social field. It is an abstract machine. […] The diagram never functions in order to represent a persisting world but produces a new kind of reality, a new model of truth.[66]

This is the understanding with which van Berkel associates his idea of the diagram with "abstract machine." Ben van Berkel defines the diagram which inherits the potential to generate novel meanings, as: "diagram is a diagram because it is stronger than its interpretations."[67] As an abstract machine, a diagram goes beyond its own substance and representation to become a generative design tool and "the diagrammatic or abstract machine does not function to represent, even something real, but rather constructs a real that is yet to come, a new type of reality."[68]

It can be asserted that the use of diagrams in the architectural design process has witnessed a shift with the introduction of diagrams as generative design tools associated with the Deleuzian concept of the "abstract machine." The analytical practice of the diagram, which is discussed in the section titled "Diagrams as

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[66] Gilles Deleuze, *Foucault* (Minneapolis: University of Minnesota, 1988), 37.

[67] Ben van Berkel and Caroline Bos, *Move-Techniques*, Vol.2 (UN Studio & Goose Press, 1999), 20.

[68] Gilles Deleuze. *A Thousand Plateaus: Capitalism and Schizophrenia*. (Minneapolis: University of Minnesota Press, 1987), 141-142.

Generative Design Tools" is now being replaced with a Deleuzian approach, in which the diagram does not end up with the definition of a fixed solution. UN Studio integrates the use of diagram as "abstract machine" into their design processes by describing the potential relationships that are distinct from material reality. Emphasizing the departure of the diagrammatic practice from the analytical to the abstract, also Stan Allen claims that:

> Unlike classical theories based on imitation, diagrams do not map or represent already existing objects or systems but anticipate new organizations and specify yet to be realized relationships. The diagram is not simply a reduction from an existing order. Its abstraction is instrumental, not an end in itself. […] Diagrams are not schemas, types, formal paradigms, or other regulating devices, but simply place-holders, instructions for action, or contingent descriptions of possible formal configurations. They work as abstract machines and do not resemble what they produce.[69]

The attention to the transformed use of diagrams in recent years has multiplied diagrammatic architectural practices that regard the diagram as an inspirational and generative tool. By emphasizing the non-representational aspect of the diagram or the abstract machine, van Berkel uses the diagrams as proliferators that are instrumental in the production of new relationships rather than using them to represent an existing object or situation.[70] A diagram, as also Ben van Berkel makes a quotation from Greg Lynn, is an "abstract machine, which can generate ways of working, instead a being used as a metaphor or reference."[71]

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[69] Stan Allen, "Diagrams Matter," *Any Magazine.* No. 23 (1998): 16.

[70] Explaining that the diagram is not representational but instrumental in the design process, Ben van Berkel indicates that the diagram is not literally taken; it is transformed to provide you with the possible relationships. Ben van Berkel (UN Studio-Amsterdam), "Interview with Ben van Berkel" conducted by the author of the thesis, September 2009. See Appendix A.

[71] "Ideogram to Diagram" Interview with Ben van Berkel. Ouaderns Espirales Spirals No:222. (Barcelona : Bosch, Casa Editorial, August 1999).

Therefore, it may be asserted that the shifted use of diagrams under the influence of the Deleuzian notion of the "abstract machine" aids to liberate design ideas from formal concerns that define a typological practice in the design process. The introduction of diagrams as generative design tools had a consequence of substituting typological practices with topological ones.

Interpretation of the second reading by Deleuze, associated with Francis Bacon's definition of the diagram, relates it to the selection, application and operation of the diagrams in the design process. Explaining the definition of the diagram in Bacon's paintings Deleuze states that:

> What is this act of painting? Bacon defines it as follows: making marks at random (brushstrokes-lines); cleaning, sweeping, or wiping places or areas (daubs-color); throwing paint at varied angles and speeds. Now this act (or acts) presupposes that there are already figurative data on the canvas (and also within the painters head) that are more or less virtual or more or less actual. These data will be precisely demarcated, cleaned, swept, and wiped, or covered over, by the act of painting. For example, we lengthen a mouth, we make it go from one side of the head to the other; we clean part of a head with a brush, a scrubbing brush, a sweeping brush, or a rag. This is what Bacon calls a *Diagram*…[72]

The way how Bacon uses the diagram in his paintings answers Deleuze's question: "What is this act of painting?" In painting, the diagram is the "act" that organizes "figurative data" in a way to generate the painting. The "figurative data" provides an order and is transformed into "painting." The tools for organizing the figurative data are the "set of brushstrokes and daubs of color, lines and areas."[73] They are not the

[72] Gilles Deleuze, "The Diagram," in *The Deleuze Reader*, edited by Constantin Boundas, 193-199 (New York: Columbia University Press, 1993), 194.

[73] Ibid.

painting itself, but they are operational tools which are irrational, involuntary, accidental, free, random, […] non-representative, non-illustrative, non-narrative" for the act of the painting that generate the painting[74] (Figure 12). Indeed, they are operational tools for the ordering of the figurative data. The diagram organizes how these tools operate on the canvas, and relates them to each other. The painting is comprised through the diagram, thus, the diagram becomes an operative tool.

Figure 12: Triptych, Three Studies of Figures on Beds, 1972, Francis Bacon

Pia Ednie Brown, "The Texture of Diagrams-Reasoning on Greg Lynn and Francis Bacon," *Daidalos- Diagrammania*, issue 74 (January 2000): 74 -75.

Bacon proposes to liberate painting from narratives, metaphors or analogies so that he would concentrate on the act of painting; thus this is the generative role of the diagram involved in painting.[75] Deleuze's reading is that the function of the diagram is to "suggest [and] introduce the possibilities of fact." [76]

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[74] Gilles Deleuze, *Francis Bacon: The Logic of Sensation* (University of Minnesota Press, October 2003), 71.

[75] In his doctoral thesis Kerem Yazgan also defines the paintings of Francis Bacon neither as abstraction nor as representation, but as action. The painting belonging to the instant of making takes shape through the act of making the painting. Kerem Yazgan, "Designography of Architecture" (Ph.D. diss., METU, 2003), 22-23.

[76] Gilles Deleuze, "The Diagram," in *The Deleuze Reader*, edited by Constantin Boundas 193-199 (New York: Columbia University Press, 1993), 194.

Bacon's diagram acts through the rhythm of these transformative impulses; it moves through painting, embodied within the paint without simply being the painting itself. As Deleuze interprets the occurrence of the diagram at the center of the painting which is loaded with structure and full of potential to reveal the painting, he states that: "One starts with a figurative form, a diagram intervenes and scrambles it, and a form of a completely different nature emerges from the diagram."[77]

In their concern of UN Studio, the diagram has a generative meaning rather than conventional analytical one and corresponds to a different stage in the process of evaluating, applying and struggling with Deleuze's "abstract machine." The selection and application of the diagram has an accurate "directness" in terms of being "suggestive" for the occurrence of new relationships. This "suggestive" aspect of the diagram can be read as infrastructural and instrumental in its implementation in the design process. Emphasizing the use of the diagrams as proliferators in the process of unfolding the architectural design strategies, van Berkel introduces the diagrams as "infrastructural" organizations which can be read as "maps of movements, irrespective of their origins." With the integration of the diagram into the design architectural design process, the elements of the design process achieve an organizational order, as with the brushstrokes, daubs of color, lines and areas in painting. In his essay "*Diagrams Matter*," Stan Allen states that, "the primary utility of the diagram is as an abstract means of thinking about organization. The variables in an organizational diagram include both formal and programmatic configurations: space and event, force and resistance, density, distribution, and direction."[78] In architecture, the diagram organizes possible relations between program, context and construction for the realization of the end product.

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[77] Gilles Deleuze, *Francis Bacon: The Logic of Sensation* (University of Minnesota Press, October 2003), 109

[78] Stan Allen, "Diagrams Matter," *Any Magazin,* No. 23 (1998): 16.

2.4. From Diagrams to Design Models

The diagram acts as an infrastructural and generative tool throughout the design process. It provides a continuous oscillation in the design process by being open to modifications, embeddings and removals of information. Because of their generative, manipulative and transformative potentials, the diagrams can be used to operate for different design processes and generate different outcomes. These outcomes can be obtained through re-definition, re-structure and re-operation of the same diagram.

Ben van Berkel introduces the diagram into design process as a form of "mediator" which defined as a generator of the design ideas and organizational potentials.[79] By developing their own diagrams and integrating them to different projects, UN Studio introduces the "Design Model" principle in which one diagram functions for different projects in different ways.[80] Manipulating and applying a number of diagrams distinctively in different design processes, van Berkel defines the "design models" as:

> […] packages of organizational or compositional principles, supplemented by constructional parameters. The design model does not include site-specific information; it exists at a more abstract level and may be implemented in various situations and projects. It is formulated in such a way that it becomes an internal point of reference that can be used for the duration of the process.[81]

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[79] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 40.

[80] UN Studio introduces a matrix that demonstrates the utilization of their diagrams as design models with different projects designed between 1989-2006 (Figure 15).

[81] Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 16.

Design Models may help to develop generative design ideas and open up novel generative relationships regarding architectural design process. Indicating the loose structure of the design models that can be integrated into the design processes in different formations, van Berkel states:

> We want these models to completely unfold in our works. Unfolding, instead of reduction. Instead of finding a single, ideal, universally usable model I want to keep it operative and experimental, it should constantly continue to develop.[82]

Any diagram such as Möbius Strip, its three dimensional variant the Klein Bottle, and the Trefoil can be manipulated and applied in different design processes and for different projects and can be concluded with different programmatic, constructional and formal outcomes.

Beside the use of more than one diagrammatic model to operate for a project, one diagrammatic design model can operate to structure more than one project. To illustrate, "Blob-to-Box" model which becomes involved in a project as a "connector of disparate systems through sectional transformation," in the design process, it provides for transformation from a strict, unit-base system (the box) to more fluent and relational system (the blob) (Figure 13). Such different systems can operate together in more than one design project at different scales: from generating the idea of the concert hall (strict-unit based system) and the foyer (relational and flux-based system) in a theatre - Music Theatre in Graz, to defining a circulation system of a house-Villa NM and to forming a pylon of a bridge - Prince Claus Bridge[83] (Figure 14).

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[82] Ben van Berkel (UN Studio-Amsterdam), interview with Ben van Berkel conducted by the author of this thesis, September 2009. See Appendix A.

[83] Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 216.

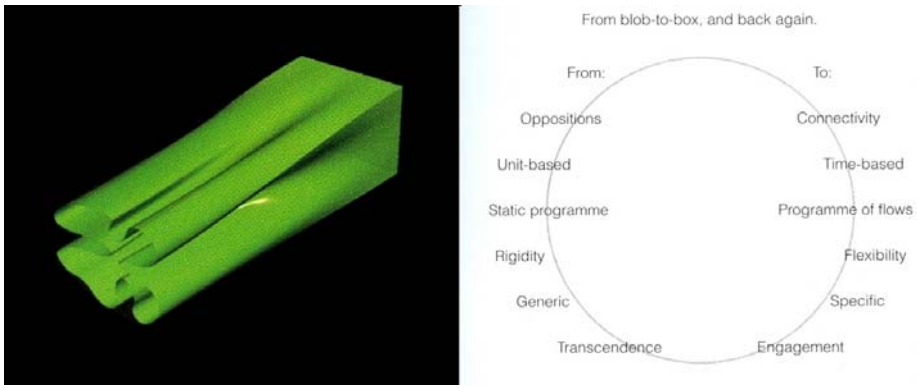

Figure 13: Blob-to-Box Model principle as an organizational structure.
Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 217.

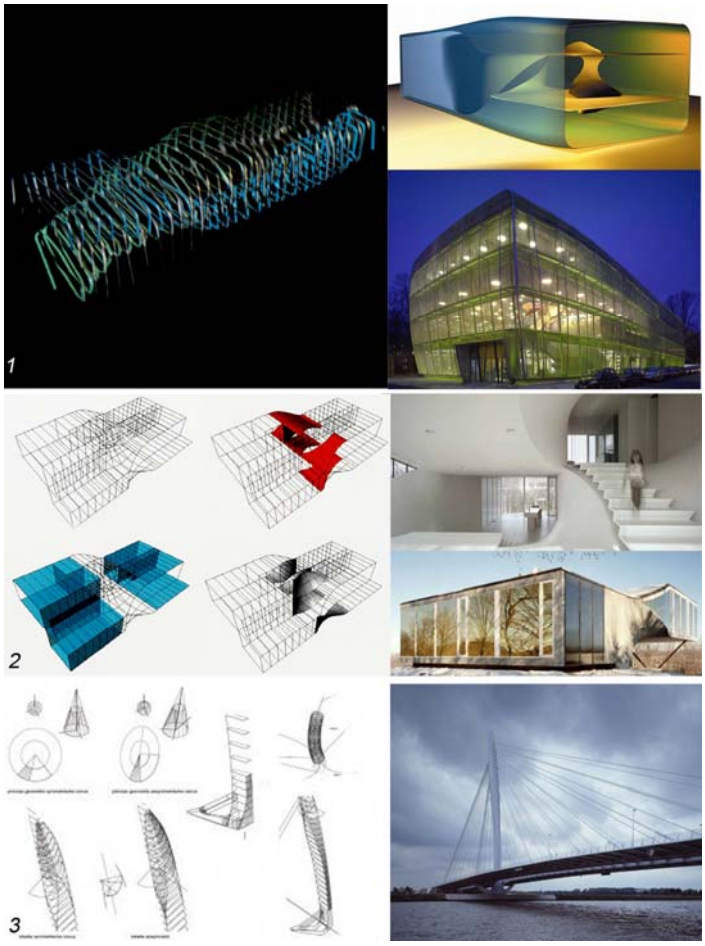

Figure 14: (1) Music Theatre, Graz, 1998-2008, (2) Villa NM, New York, 2000-2007, (3) Prince Claus Bridge, Utrecht, 1998-2003.
Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 255-256 and 79-81.

The design models operated in more than one project are used to define a generative architectural design process and offer ways of working during the process. In that respect the definition of "design models" that UN Studio introduces may correspond to "design acts" that Kerem Yazgan explores precisely in his doctoral thesis.[84] Indicating that every discipline requiring acts that operate in a process, such as process of making movie that utilizes acts like "line doubling, color encoding, sampling, quantization, etc.," Yazgan proposes that acts can be operated and manipulated in the process of making design in the same way that they are defined in cinematography.[85] In his thesis, Yazgan aims at proposing development of a research area called "*Designography*" where identification and configuration of acts of design are opened up in the architectural discipline.[86]

Ben van Berkel also gives the same example by referring to "film stills" that enable to make the film making process instrumental in the operation of ideas. Emphasizing that the artists are a step ahead of architects in developing design methods, van Berkel has begun to discover a way to generate a design process with the operation of "design models." In order to be able to handle complex cases in the design process, "design models reduce this complexity and developing a disciplined way of working."[87] However, UN Studio defines their design process not directly by the design acts, as Yazgan proposes in his thesis, but by introducing their "design models" which inherit the potential of producing the design acts.

Moreover, evaluating the "design models" as organizational structures that enable the designer to structure the architectural design process, van Berkel defined them as tools that may aid to generate and develop novel design ideas specific for the

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[84] Kerem Yazgan, "Designography of Architecture" (Ph.D. diss., METU, 2003).

[85] Ibid, 54.

[86] Ibid, 56.

[87] Ben van Berkel (UN Studio-Amsterdam), interview with Ben van Berkel conducted by the author of this thesis, September 2009. See Appendix A.

designer (Figure 15). Defining the "design models" as the solution of the requirement for new skills and new ways of imagining and realizing construction, van Berkel states:

> The solution presented here is based on our experiences, as architects of both failed and realized projects and as educators, which have convinced us that architects can train themselves to generate their own touchstones, or 'design models', that summarize a set of principles to help them select and implement the right parameters and remain true to their own vision.[88]

Similarly, by emphasizing the potential of the "design acts" for architects Yazgan states "by developing his/her own acts, or his/her own use of already defined acts, and related strategies and tactics, one may experience and evaluate his/her own individuality."[89] In other words, determining one's own generic and specific "design models" one can identify his/her own design process similar to a design process identified by acts of design.

In the later chapters how a diagram as infrastructural and generative tool operates in different design processes and generates distinct design ideas will be tried to be explored. Based on a transformative interpretation of a single topological structure, the Möbius Strip, its three dimensional variant the Klein Bottle, and the Trefoil diagrams are aimed to be examined in terms of how they generate, operate and manipulate different design processes and to be concluded with different programmatic, constructional and formal outcomes: Möbius House, Arnhem Central Station and Mercedes Benz Museum.

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[88] Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 10.

[89] Kerem Yazgan, "Designography of Architecture" (Ph.D. diss., METU, 2003), 58.

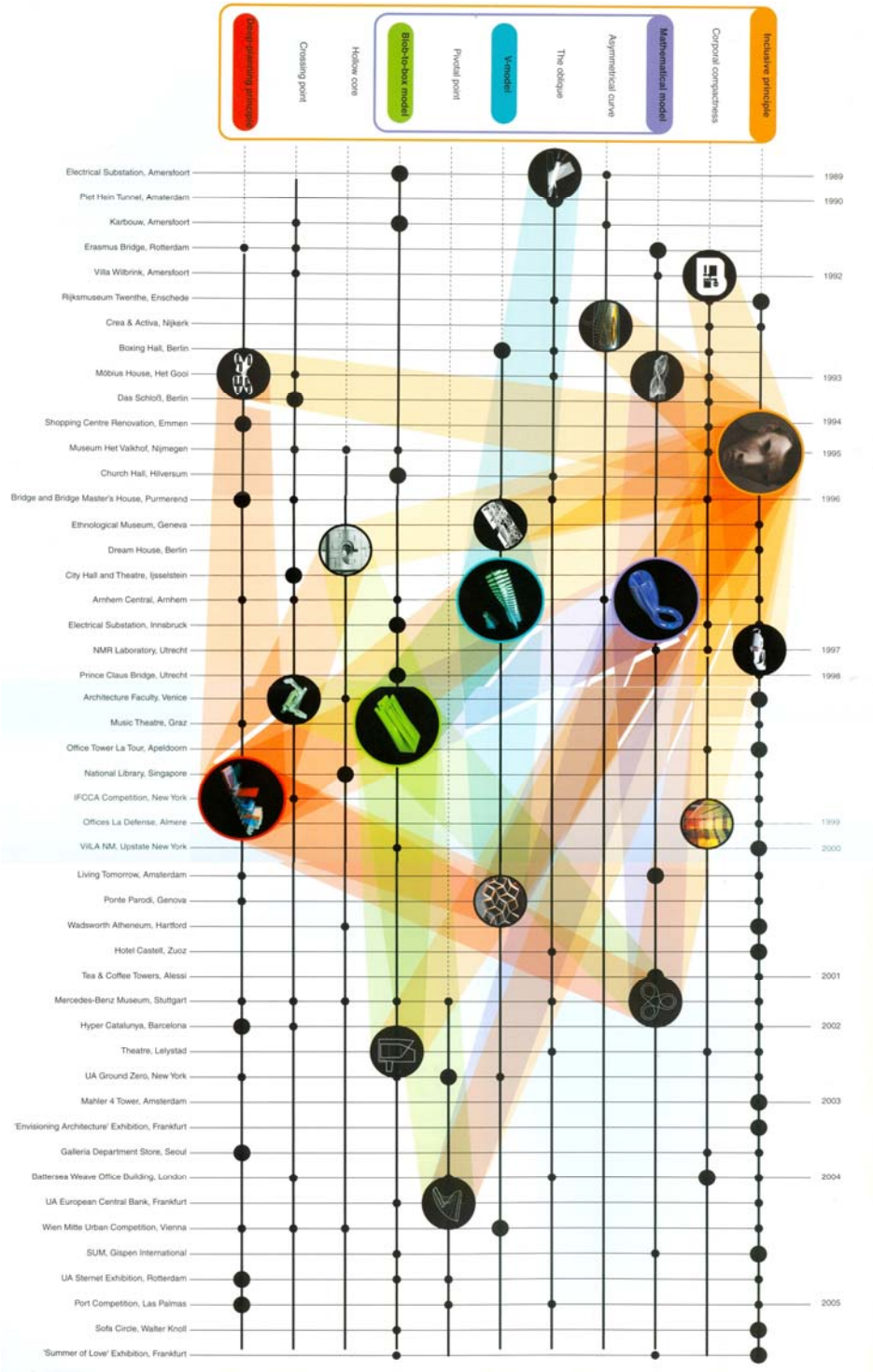

Figure 15: Matrix of diagrams used by UN Studio that shows multiple use of diagrams as Design Models for different projects.
Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 22-23.

CHAPTER 3

MÖBIUS HOUSE, HET GOOI-NETHERLANDS, 1993-1998

The Möbius House by UN Studio was the first completed project among the other three in connection with which the role of the Möbius Strip diagram as a generative design tools in the design process will be discussed. This project significantly triggers the research questions about the roles of the diagrams in the construction of design ideas and their evolution during the design process.

This chapter focuses mainly on four issues about the Möbius House project in order to unfold the diagram-oriented design strategy of UN Studio concerning it. These issues are also dwelt on in the study of the other two projects as well so that a comparative analysis of their design processes can be done. Firstly, detailed information will be provided about the building and the ideas related to its context. Secondly, the developments that have led to the use of the Möbius diagram and its conceptualization will be introduced. Thirdly, the evolution of the design ideas will be explored in order to be able to describe the significance of the use of the diagram. Finally, the role of the diagram in the realization of the project will be discussed with reference to the construction of the building.[90]

[90] The structure which comprises the content of case studies borrowed from Fehmi Doğan's thesis in which the case studies used for exploring the "conceptual diagram" in evolution of their design process. Fehmi Doğan, "The role of conceptual diagrams in the architectural design process: Case studies of the First Unitarian Church by Louis Kahn, the Staatsgalerie by Stirling and Wilford Associates, and the Jewish Museum by Daniel Libeskind" (Ph.D. Dissertation, Georgia Institute of Technology, 2003).

The Möbius House, among other projects of the studio to date is an important project in terms of being an initial example of a well-known building where a mathematical knot has been used as a diagrammatic model of the whole design idea. A wide range of publications allocate their specific chapters to the design strategy of the Möbius House because of its triggering diagram, the "Möbius Strip." Therefore, it is also significant for the UN Studio's professional and intellectual career. Literally, the design process of the Möbius House has aided to formulate Ben van Berkel's idea of the diagram as a generative tool with the publication of a book, an interview that has taken place in an architectural magazine, and an article during the five years that the design process has continued - from1993 to1998.[91] In these publications Ben van Berkel defines the design philosophy of his studio in which the diagrams play a significant role in their design process with reference to the design strategies of the Möbius House. The publications are profoundly theoretical statements of the studio concerning diagrams, rather than being a conventional architectural monograph. Thus, it can be understood that Möbius House project has been a crucial breaking point in the design strategies of Ben van Berkel and his design studio during this period of its design process.

3.1 Context

The Möbius House project is located in a region called Het Gooi which is close to Amsterdam and contains some of the finest residential neighborhoods in Holland. Surrounded by beech trees on both sides and meadows in the middle, it is in an

[91] Ben van Berkel's first book on "Mobile Forces" precisely focuses on the initial idea of the diagram in the design process of UN Studio; Ben van Berkel: Mobile Forces/Mobile Kräfte, Wiley-VCH (November 1994); El Croquis Magazine dedicated its 72th issue to the projects of UN Studio and also included a long interview with Ben van Berkel conducted by Greg Lynn. Ben van Berkel. "Ben van Berkel 1990-1995." *El Croquis*, (May 1995): 6-15; series of critical essays assembled in a specific issue "diagram" in 1998 in Any Magazine, Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation," *Any Magazine,* No. 23 (1998): 19-23.

unusual area existing in the northern slope of a small valley which is the least constructed part of the region[92] (Figure 16).

The area is unique for Netherlands due to the fact that it was quarried many decades ago for sand. The resultant terrain of dunes has made the area challenging for the project. [93] Although, the area has an undulating topography, UN Studio found a way to deal with it by introducing the Möbius Strip as a "diagram."

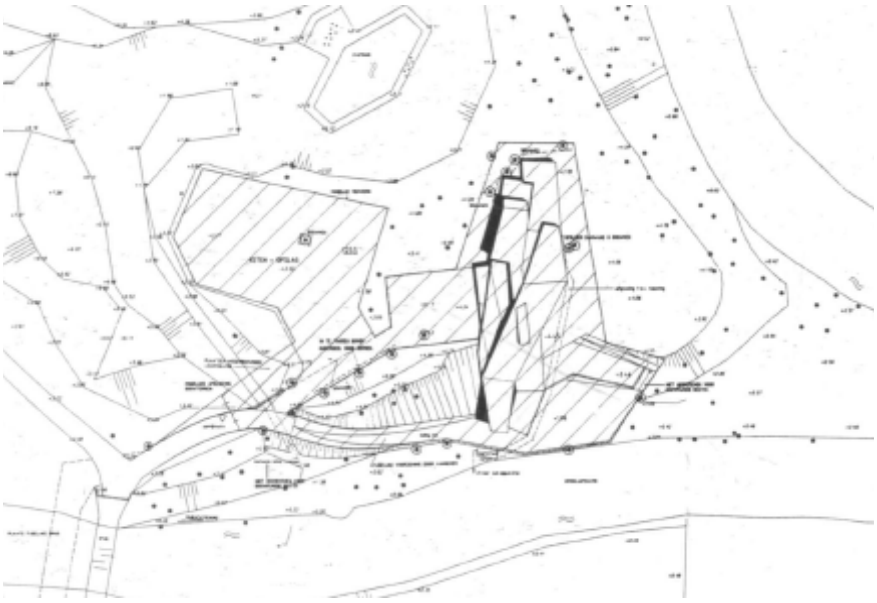

Figure 16: Site Plan of Möbius House

Ben van Berkel. "Untitled Editorial." *El Croquis* Vol 72-1 (May 1995): 86.

Ben van Berkel chose to design a proposal compatible with the problematic terrain in an adaptable way. Therefore, the exploration of the contextual qualities of the plot became significant as well as the program structuring in designing with the site (Figure 17). While explaining how and when "Möbius Strip" came up as a diagram

[92] Bart Lootsma, "Casa unifamiliare Möbius, 't Gooi, Paesi Bassi/Möbius one-family house, 't Gooi, The Netherlands," *Domus*, Vol:814 (April 1999): 45.

[93] Ibid.

and how it informed the initial design process, Ben van Berkel refers to the locational factors:

> If we refer to the Möbius House, the diagram is not introduced into the design process as: We found a diagram, so let's make a house of it! What often happens is that the diagram is a tool what goes in the process, like in the phases of the Möbius House. In the case of Möbius House, we first looked at the location and we had four *quadrum.* Therefore, we propose a cross into the location because of the four different qualities of landscape. Then out of the cross we thought about how it can be linked together. So we come up with the idea of drawing a circle in the cross that can be twisted. That is one of the reason that we come up with the Möbius strip idea.[94]

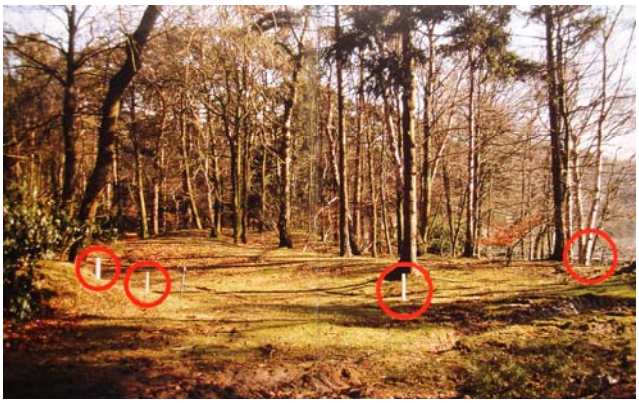

Figure 17: Contextual first step before leading to the Möbius Strip: The cross-plotted on the site.

Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999): 44-45.

Covering approximately 600m^2, the area was divided into four areas distinct in character. Linking those four differently qualified points with the Möbius Strip idea,

[94] Explaining that the diagram is not representational but instrumental in the design process, Ben van Berkel indicates that the diagram is not literally taken; it is transformed to provide you with the possible relationships. Ben van Berkel (UN Studio-Amsterdam), interview with Ben van Berkel conducted by the author of this thesis, September 2009. See Appendix A.

which will be elaborately explored under the latter title, has aided to define an internal organization of the program and to transform "living in the house into a walk in the landscape.[95] Therefore, it can be stated that the site and its relationship with the building has led to the implementation of the Möbius strip into the building.

Besides the contextual site exploration and its given outputs, there is a second reason for the emergence of Möbius Strip diagram. It has stemmed from an investigation to find a structure that would contribute to the program. Having an "equivalent importance" with the site relationship of the diagram, 24 hours of family life with the time-space relationship has triggered the generation of the diagram, Möbius Strip, which would aid to acquire the program structure containing work, social life, family life and individual time.[96]

In 1993, the clients, a working couple - now apart with two children - asked the architects for an "unusual house": three bedrooms, a meeting room and kitchen, storage and living room, two studios and spaces to share common hours. The clients defined the house as "unusual" due to the fact that they insisted on a house which would not be meaninglessly big as the other private houses around and would be part of the landscape. In addition to the wishes for an intense relationship with the landscape, the clients asked for a "new life style" as their two distinctive professions allowed them to work at home and therefore to spend more time with their children.[97]

Morever, van Berkel planned the villa to utilize all the aspects of landscape including the daily cycle of the sun and the changing seasons. Every part of the program has a different setting with a specific quality. The aim of this organization

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[95] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 43.

[96] Ibid, 40.

[97] Ben van Berkel. "Untitled Editorial." *El Croquis*, (May 1995): 86.

was to design a new type of dwelling which would also compatible with the features of the district.

Ben van Berkel elaborated the space organization by introducing a program structure that contained work, sleep, socialization and family life, as well as the need to be alone. The idea of two people living along their own routes but sharing common periods together was built into the structure of the house. The house knit together the different activities which each member of the family was involved in at different times in a pattern that called forth the Möbius Strip diagram:

> The idea was to have a cross movement going on the location where you move from- let's say one part of the landscape to the other or lets say one part of the house to the other. The idea of cross-structuring of information applied to the construction of the house, organization of the geometry. The program and the routing are also integrated by the diagram. So that living working and sleeping would be coming together in the one coherent structure; in the Möbius Strip.[98]

3.2 An Introduction to Möbius Strip and Its Use as a Generative Design Tool

Möbius strip was named after the German astronomer and mathematician August Ferdinand Möbius in September 1858 (1790-1868). However, records state that the first known discovery of the Möbius strip was made in July 1858 by Johann Benedict Listing (1808-1882). The official discovery is credited to be Möbius's 1865 paper titled, "On the Determination of the Volume of A Polyhedron."[99]

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[98]Ben van Berkel (UN Studio-Amsterdam), "Interview with Ben van Berkel" conducted by the author of the thesis, September 2009. See Appendix A.

[99] Clifford A. Pickover, *The Möbius Strip: Dr. August Mobius's Marvelous Band in Mathematics, Games, Literature, Technology, and Cosmology* (Thunder's Mouth Press, New York, 2006), 28.

The Möbius strip is a topological and non-orientable structure which consists of one-sided surface in the form of a single closed continuous curve with a twist.[100] It is obtained from a single strip by giving it a half-twist, and then joining the ends of the strip together to form a loop. One-sidedness of the Möbius strip exploits a remarkable property of a non-orientable surface. Joining A to C and B to D without a half-twist would produce a simple belt-shaped loop with two sides and two edges which is not possible to reach from one side to the other without crossing an edge. However, with a half twist, the Möbius Strip has only one side and one edge.

Beyond its mathematical and topological context, Möbius Strip also affects various realms such as, magic, engineering, science, art, music, cinema and literature, and is used either in its true form or as a metaphor. Interestingly, the first "application" of the idea that can be found in the records outside of mathematics is in the realm of magic.[101] In engineering, the Möbius strip found its reflections as Möbius filmstrips in 1923 by Lee De Forest which is the same idea later applied to tape recorders so that a twisted tape would run twice as long as it turns other side. The cinema industry, too, recently used the idea of the Möbius. The movie *Möbius*, directed by Gustavo, and *Eternal Sunshine of the Spotless Mind*, directed by Michel Gondry in 2004, featured the strip as the structure of the scenes.

Möbius Strip's most revolutionary effects were perceived in art. The evolution of the Möbius Band as an art form was first seen in the "Endless Ribbon," a granite sculpture in 1935 by Max Bill who was an architect, a sculptor, a painter, and a

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[100] The non-orientable surface is any surface which one cannot define the notions of "right" and "left" and come back to its starting point as a mirror image. As in the Möbius Strip example, closed non-orientable surfaces which have no inside and outside cannot be constructed in Euclidean spaces. The non-orientable geometries only exist and are constructed in non-Euclidean spaces. See more: Harold Scott Macdonald Coxeter, *Non-Euclidean Geometry* (Washington, Mathematical Association of America, 1998).

[101] Pickover referred Martin Gardner's book titled *Mathematics, Magic, and Mystery* (1882), as the earliest reference for use of the Möbius strip as parlor trick - an easy magic trick, in 1882. Clifford A. Pickover, *The Möbius Strip: Dr. August Mobius's Marvelous Band in Mathematics, Games, Literature, Technology, and Cosmology* (Thunder's Mouth Press, New York, 2006), 3.

graphic artist. Afterwards, Dutch graphic artist M.C. Escher, concentrating on topological surfaces and seeing the Möbius strip as a paradoxical object, painted a number of variations, such as Möbius Strip II (Red Ants) in 1963 with the nine red ants that seem to crawl on an endless loop. The symbol for recycling, which is a graphic representation of the Möbius, was selected after a competition in 1970 conducted by the Chicago-based Container Corporation of America. In 1974, Robert R. Wilson constructed a sculpture called "Möbius Strip" for the Fermi National Accelerator Laboratory of Illinois. İlhan Koman, who has tried to find a different approach to his art with mathematical and structural assumptions, has investigated the 3D interpretations of Möbius Strip in his sculptures. More recently, Tom Longtin modified the Möbius Strip by using 3D computational design in order to design the sculpture "Möbius Helix" (Figure 18). Many other artists who were inspired by the form of this strip, including Brent Collins, Helaman Ferguson, Cliff Long, Charles Perry, John Robinson, Keizo Ushido, and Robert Rathbun Wilson also sought the form of endlessness, non-orientability in their works.[102]

[102] The order of the artists' names is borrowed from: Jolly Thulaseedas and Robert J Krawczyk, *Möbius Concepts in Architecture* (Illinois Institute of Technology). See more information on the artists' works:
Max Bill, "*The Mathematical Way of Thinking in the Visual Art of Our Time" in The Visual Mind: Art and Mathematics,* edited by M. Emmer (MIT Press,1993): 5-9; M. C. Escher, J. L. Locher and W. F. Veldhuysen, *The Magic of M.C.Escher,* (Harry N. Abrams, 2000) 339-342; Ivars Peterson, *Fragments of Infinity: A Kaleidoscope of Math and Art* (John Wiley & Sons, 2001); İlhan Koman, *Retrospective* (İstanbul: Yapı Kredi Yayınları, 2005), 98; Longtin, Tom, *Moebius Helix*, http://www.sover.net/~tlongtin ((last accessed in February 2010); Collins, Brent and George K. Francis, "*On Knot Spanning Surfaces: An Illustrated Essay on Topological art" in The Visual Mind: Art and Mathematics,* edited by M. Emmer (MIT Press, 1993): 59-61; Helaman Ferguson, *The Umbilic Torus*, USA, http://www.helasculpt.com (last accessed in February 2010); Peterson, *ibid.*,143-144; Charles Perry, "*In The Edge of Science: The Role of the Artist's Intution in Science*" *in The Visual Mind: Art and Mathematics,* edited by M. Emmer (MIT Press, 1993): 59-61; John Robinson, *Dependent Beings*, Spain and *Eternity*, Australia, http://www.johnrobinson.com (last accessed in February 2010); Keizo Ushido, *Aji*, Japan *Mure,* Japan and *Stone Möbius*, New Zealand, http://www2.memenet.or.jp/~keizo (last accessed in February 2010); Peterson, *ibid.*, pp. 148-149.

Figure 18: Endless Ribbon by Max Bill, Möbius Strip II by M.C. Escher, symbol for recycling by Gary Anderson, Möbius Strip Sculpture by Robert R. Wilson, Untitled Möbius Derivative by İlhan Koman, Möbius Helix Sculpture by Tom Longtin

There are also three-dimensional, functional structures that actually and representatively use the potential of the Möbius Strip's mathematical accuracy. The Möbius climbing toy designed and constructed by a mathematics professor, Gerald Harnett, in Sugar Sand Science Playground in Boca Raton, Florida in 1999 was an investigation of the Möbius strip as an enclosure. It consists of 64 differently sized triangles linked together and resting on 17 pipes in a twisted structure[103] (Figure 19).

Figure 19: Möbius Climbing Toy

Ivars Peterson, http://www.sciencenews.org/sn_arc99/5_22_99/mathland.htm (last accessed in May 2010).

In architecture, Peter Eisenman pioneered the Möbius form by translating it into the "Max Reinhardt Haus" building after the Berlin wall was removed in 1991. Rising

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[103] Peterson Ivars, *Möbius in the Playground*, http://www.sciencenews.org/sn_arc99/5_22_99/mathland.htm (last accessed in May 2010).

thirty four stories in 100,000 m², including offices, hotel spaces, auditoriums, fitness center, a restaurant, the building was formed by the operations performed on the form of Möbius Strip (Figure 20). A three dimensional endless form allows two dimensions to be folded into a single surface by twisting on itself. Using the Möbius Strip's inside and outside relationships, the building achieves a distinction between the public and the private. Thus, the Möbius Strip was utilized with the concerns of representing the structure, not for the generation of the design process from concept to realization. In this sense, the building's conceptualization is different than UN Studio's design strategies of using the generative idea of the Möbius Strip during the design process of the Möbius House project.

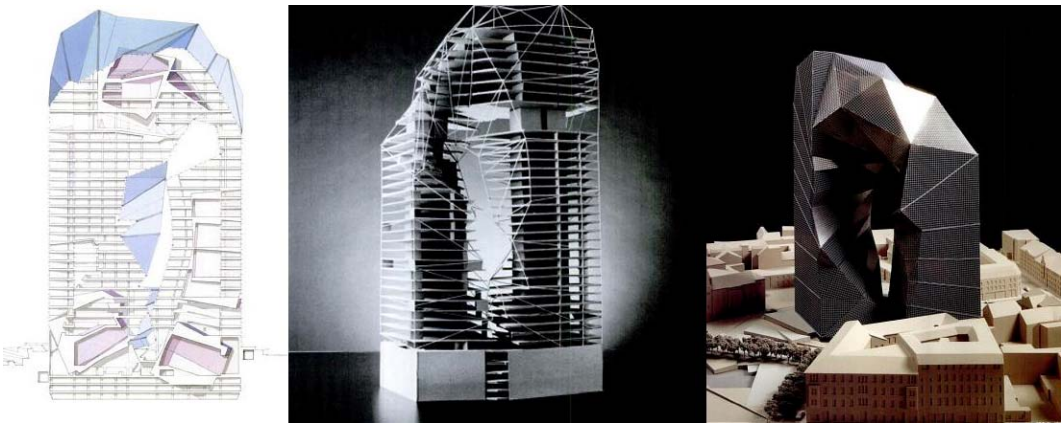

Figure 20: Max Reinhardt Haus in Berlin

Guy Nordenson and Terence Riley, *Tall Buildings* (The Museum of Modern Art, 2003): 43-45

The generative potential of the Möbius Strip, in respect of this thesis, was investigated in the first year design studio of the Department of Architecture at METU. For an exercise that aimed at acquaintance with and experience of the variety of rhythmic organizations, it was considered an appropriate diagram for the students to generate their design processes. Students were asked to achieve a "path of movement" which would connect a rhythmic series of volumes that were

expected to be created by planes. The volumes were to be physically interrelated to enable movement from one to the other to achieve a rhythmic organization with the sizes and shapes of the volumes developed in the process. Materialized by timber stick-form elements which were to be repeated at 2cm intervals, and cardboard, volumes would be organized based on the movement of an automaton in an endlessly repeating cycle.[104]

The problematic of the above mentioned exercise seems relevant to the theme of this thesis, in terms of the operation of the Möbius Strip as a diagram that is generative and instrumental for novel design ideas. The generative potential of the Möbius Strip triggers the design process operating as an infrastructural tool for volumes, planes, automaton and the sun. [105]

3.3 Evolution of the Diagram throughout the Design Process of the Möbius House

The utilization of the Möbius Strip in the Möbius House project is not as a representational image of itself, but as generator for the design process. Indicating the significance of the diagrams as suggestive and proliferating tools in the architectural design process van Berkel refers to the Möbius Strip:

> The instrumentalization of this simple, borrowed drawing is the key. The two interlocking lines are suggestive of the formal organization of the building, but that is only the beginning; diagrammatic architecture is a process of unfolding and ultimately of liberation. The diagram

[104] The problem definition of the project is provided by Assoc.Prof.Dr. Selahattin Önür who is one of the instructor of the first year architectural design studio in METU and also the advisor of this thesis.

[105] For the selected final projects of first year design studio see Appendix D.

> liberates architecture from language, interpretation and signification. [106]

Using a Paul Klee drawing as a starting point of the Möbius diagram, Ben van Berkel and Caroline Bos have generated the lines of circulation in the building as in Klee's lines which curve in and out[107] (Figure 21).They use Klee's drawing as proliferator for the emergence of the Möbius Diagram with which the fluidity of the programs was conceptualized. How the Möbius strip was instrumentalised in the design process is described by Ben van Berkel and Caroline Bos:

> The mathematical model of the Möbius is not literally transferred to the building, but it conceptualized or thematised and can be found in architectural ingredients, such as the light, the staircases and the way in which people move through the house. So, while the Möbius diagram introduces aspects of duration and trajectory, the diagram is worked into building in a mutuated way.[108]

As mentioned above, the exploration of the site qualities and the concern to find a structure which would contribute to the program have directed the designers to use the Möbius diagram as a generative tool (Figure 22). Due to the fact that the Möbius Strip is a one-sided topological surface geometry without any thickness and lack of volumes, Ben van Berkel has started with transforming the diagram

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[106] UN Studio, http://www.unstudio.com. (last accessed in August 2010).

[107] The second drawing in figure 21 is also illustrated by Ben van Berkel by referring to analysis of Deleuze in: Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 41. Paul Klee drawing is also explored by Deleuze. Deleuze refers to the drawing of Paul Klee in order to define "inflection" as the ideal genetic element of the variable curve and fold, what Klee extracts as ideal genetic elements of a spontaneous line. "The first line draws the inflection. The second shows that no exact and unmixed figure can exist. The third marks the convex side with shadow, and thus disengages concavity and the axis of its curve, that now and again changes sides from the point of inflection."
Gilles Deleuze, *The Fold: Leibniz and the Baroque*, (University Of Minnesota Press, 2006), 16. The original image can be found in Paul Klee, *Theorie de l'art* moderne (Paris: Gonthier, 1963), 73.

[108] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 43.

topologically.[109] Without any change in the qualitative properties of the generative diagram, he has introduced a "double-locked torus" generated from the idea of the Möbius Strip that has helped to identify the trajectories of time, movement and construction.[110]

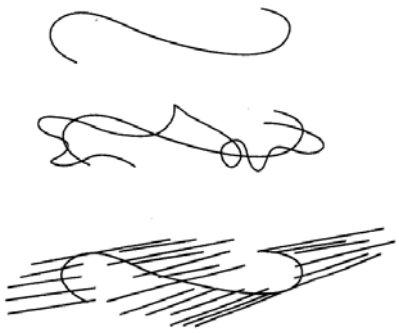

Figure 21: The drawing by Paul Klee

Gilles Deleuze, *The Fold: Leibniz and the Baroque*, (University Of Minnesota Press, 2006): 16.

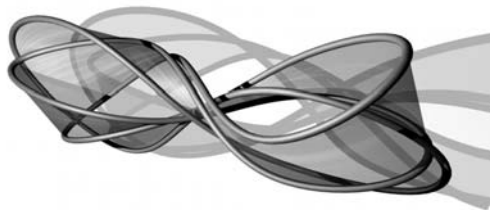

Figure 22: Möbius Diagram

Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999): 45.

The diagram indicates the activities in the house distributed around the Möbius strip in a twenty-four hour cycle (Figure 23). Although it is called as a Möbius strip,

[109] Topological transformations are studies that concern the transformation of the quantitative properties of geometric forms without affecting their qualitative and relational properties. In the second chapter, under the subtitle 2.2.2.1 "Topological Tendency in the Generative Architectural Design Process" the topological meanings of the diagrams and their transformations in the design processes are explored.

[110] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999): 40.

when looked at the house itself, it is a “double-locked torus” which integrates program, circulation and construction into one structure.[111] Therefore, the structure enables the use of time in relation to the distribution of the program. Different activities are condensed into one single structure where work, social life, family life and individual time participate in the definition of the one loop structure. Movement through this loop follows the pattern of a single day. The surface integrates the program, infrastructure, construction, events and time. [112]

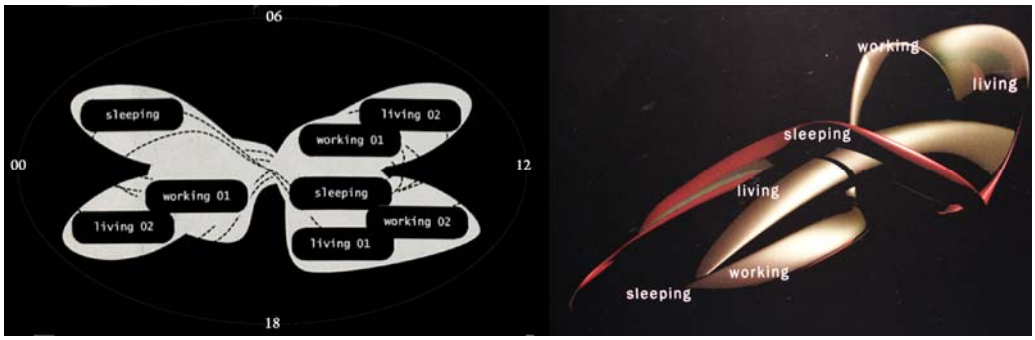

Figure 23: 24 Hours of Family Life participated into Programmatic Loop, Orientable Surface Diagram

Ben van Berkel and Caroline Bos, *L'Architecture d'Aujourd'hui* No.321, (March 1999): 78-79.

The diagram provides the villa with a principle for organizing space and also structuring the organization along a continuous route. The route runs via a hall on which the main entrance, main bedroom and the office of the male occupant are situated. The path continues with a corridor defined on one side by a long glass wall that runs along the kitchen and a large dining area to the two living areas where the ceiling and floor shift at the center. From there it doubles back on itself via a staircase and climbs a half level to the top storey. Then it passes by the office of the female occupant, children’s bedrooms and a bathroom. This corridor continues to

[111] Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 40.

[112] Ben van Berkel and Caroline Bos, *Move*, Vol.3 (UN Studio & Goose Press, 1999), 19.

another second staircase that descends to the second-floor entrance hall to complete the circuit by linking to the main entrance and to the male's office again (Figure 24).

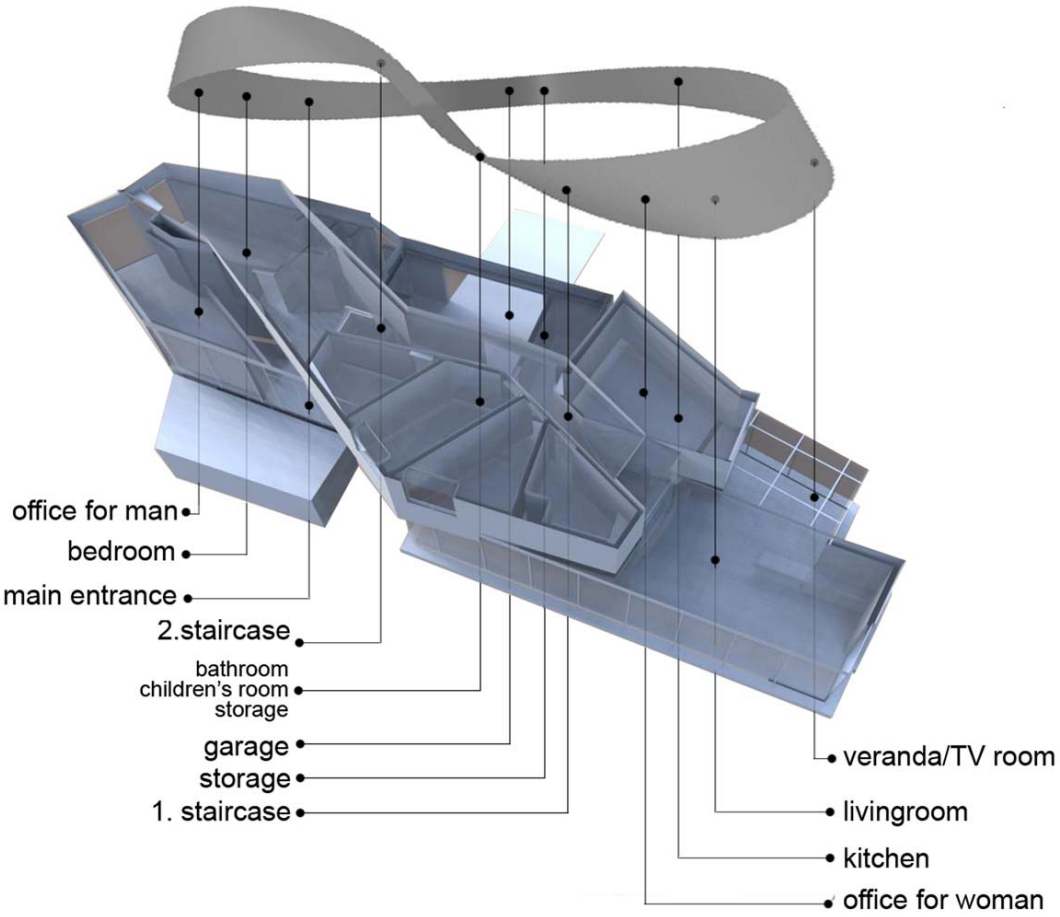

Figure 24: Distribution of programs via Möbius Strip.

The 3D model of the house and the graphic representation modeled by the author of the thesis.

Structured with the information gathered from the daily life activities of the inhabitants, the movement through the double-locked torus generates the organization of the activities around a continuous loop (Figure 25). The idea of "cross-structuring" of information is also applied to the construction of the house.[113] This diagram has initiated the idea of working with two materials, concrete and glass, and of using the notion of time in relation to the distribution of the program. The unfolding of time and the internal regulation of the program are related to the concept of the double locked torus. Uninterrupted interweaving of different functions has been constructed in the development of the continuous loop.

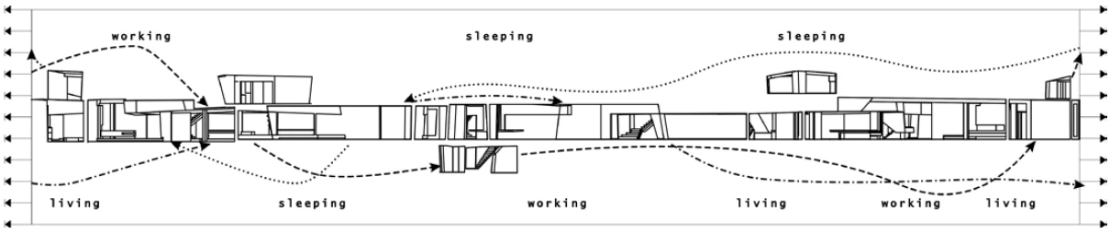

Figure 25: Unfolded Concrete Structures with Time Lines, Uninterrupted interweave of different functions

Ben van Berkel and Caroline Bos, *Move*, Vol.2 (UN Studio & Goose Press, 1999), 45.

As the loop turns inside and out, the materialization follows these changes as well. Concrete construction swaps role with glass, and vice versa. Exterior concrete become glass dividing walls and exterior glass facades become inside partition walls. Exterior concrete shell becomes interior furniture - such as tables, benches and stairs. Therefore, perception of movement is reinforced by the changing positions of the two main materials - glass and concrete - overlapping each other and switching roles (Figure 26-27-28-29-30-31).

[113] Ben van Berkel (UN Studio-Amsterdam), interview with Ben van Berkel conducted by the author, September 2009. See Appendix A.

Between the articulated and displaced forms margins are created with spatial qualities and visual axes. Fissures and voids aid to define unexpected light and space relationships. For example, the fissure between the office of the male occupant and main bedroom caused by the intersection of the Möbius strip provides an inaccessible void that enables the penetration of light.

Although van Berkel and Bos claim that they deliberately avoid representation of the Möbius strip in the construction of the building and also avoid an architecture that is based on representation, there are critics who indicate that Möbius Strip was not used into the building in a mutuated way and was not transformed topologically. As Prof. Dr. Kari Jormakka, who is a Finnish architect, historian and a critic in Vienna University of Technology and in Bauhaus-Universität Weimar, criticizes the approaches of UN Studio in the Möbius House project:

> However, architecture is not free of metaphor: the Möbius House tries to evoke ideas of continuity with standard architectural means (large windows connecting the interior with the exterior, for example) without having any of the topological qualities of the ideal diagram.[114]

According to the criticism of Jormakka the diagram can only be explained in this project as a form of metaphor. He stated that the transformation of the diagram as a topological structure in the design process is representational, thus, as a form of representation the diagram represents the geometrical qualities of the Möbius Strip. This counter argument, on the other hand, is opposed to Ben van Berkel's idea of

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[114] Kari Jormakka, *Genius Locomotion* (Vienna: Edition Selene, 2005), 179.

The idea was also argued by Kari Jormakka in the course - "Un/weaving a Rainbow - Generative and Analytic Diagrams in Architectural Design" - that was taken in the Bauhaus-Universität Weimar by the author of the thesis in Spring 2009.
Unpublished research paper by Başak Kuyumcu, "From Diagram to Practice: A Reconsideration of the Architectural Representation Process of Möbius House," (Bauhaus-Universität Weimar, July 2009).

diagram who explains that the diagram is not representational but instrumental in the design process.[115] Van Berkel also criticizes the representational technique since it causes the fixation of typology in the design process by the superimposition of the form and content in architectural design. [116] He implies that diagrammatic practice delays the typological concerns and provides suggestive and instrumental design ideas that trigger the architectural design process.

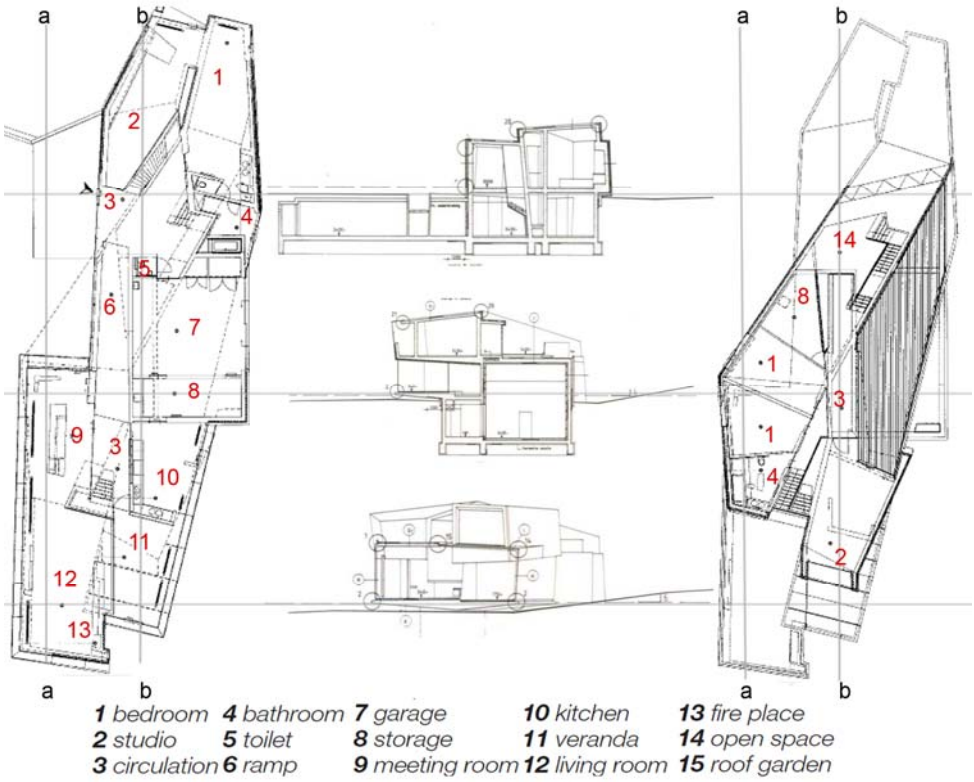

Figure 26: (Left) Groundfloor plan, (Middle) Cross sections, (Right) Upper level plan

Ben van Berkel. "Untitled Editorial." *El Croquis* Vol 72-1 (May 1995): 88-91.

[115] Ben van Berkel (UN Studio-Amsterdam), "Interview with Ben van Berkel" conducted by the author of the thesis, September 2009. See Appendix A.

[116] Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation," *Any Magazine,* No.23 (1998): 21.

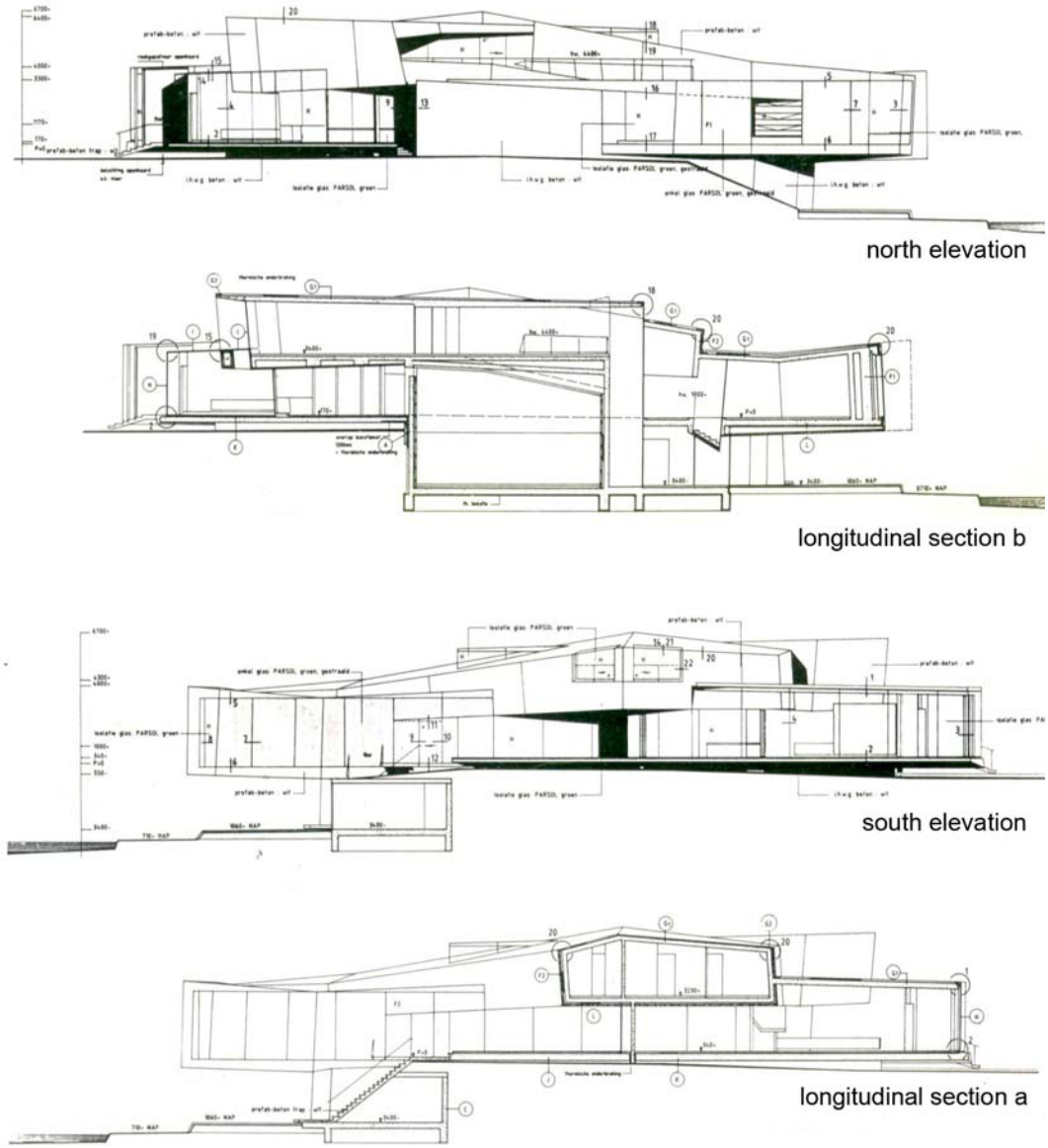

Figure 27: Elevations and longitudinal sections

Ben van Berkel. "Untitled Editorial." *El Croquis* Vol 72-1 (May 1995): 88-91.

Figure 28: North elevation of the Möbius House

http://www.archi-europe.info/Archinews/032006/newsletter03_it.htm (Last accessed July 2010)

Figure 29: North-west elevation

Bart Lootsma, "Casa unifamiliare Möbius, 't Gooi, Paesi Bassi/Möbius one-family house, 't Gooi, The Netherlands," *Domus*, Vol:814 (April 1999): 41.

Figure 30: South-west elevation

Bart Lootsma, "Casa unifamiliare Möbius, 't Gooi, Paesi Bassi/Möbius one-familyhouse, 't Gooi, The Netherlands," *Domus*, Vol:814 (April 1999): 44-45.

Figure 31: The staircase that connects the living room to second floor.

Ben Van Berkel and Caroline Bos, *Move Vol2* (Amsterdam: UN Studio & Goose Press, 1999), 64-65.

3.4 Discussion

The diagram integrated into the design process can be asserted as the generator of the project. The organizational structure of the house is based on a double-locked torus that integrates the program seamlessly, both in terms of circulation and structure. Inheriting a spatial quality, the diagram refers to a movement that has been generated by the activities where work, social life, family life and individual time participate in the definition of the one loop structure. The Möbius Strip has been used as a conceptual reference, since it could enable the use of time in relation to the distribution of the program. Thus, different activities have been condensed into one single structure.

The Möbius strip diagram can be interpreted as an "abstract machine" in operation. The selection and application of the diagram is specific in terms of being "suggestive" for the occurrence of new relationships defined by the program. This "suggestive" aspect of the diagram can be read as infrastructural and instrumental in its implementation in the design process and as proliferator of design ideas.

It cannot be asserted in this project the diagram is used free of metaphor, as discussed by Jormakka. As a form of representation the diagram represents the geometrical qualities of the Möbius Strip as opposed to what Ben van Berkel asserted. However, the diagram still remains to provide suggestive and instrumental design ideas that trigger the architectural design process. It can be asserted that the diagram operates in the design process as an infrastructural tool that enables the generation of the design ideas and construction of the context, program and structure.

However, as a tool, the diagram not only represents the geometrical qualifications of the Möbius Strip but also generates an infrastructure for the design process from concept to construction. The topological transformation of the Möbius Strip into a

design process provides the introduction of the diagram into the all phases of project in a mutuated way.

As a proliferator of the design ideas the diagram is instrumentalized in the design process in order to generate the spatial qualities indicating the activities in a day in one loop structure. Thus, this structure integrates the program, construction, events and time into a single continuous route. In this aspect the diagram for the Möbius House, the Möbius strip, can be asserted to responsible for the proliferation of the design process and can be considered as a generative tool by triggering to define novel relationships for a creative design process.

The diagram of Möbius House project is significant in that it has helped the designers to structure the design situation and to lay out the general characteristics of the design solution. Its importance in problem structuring and problem solution simultaneously facilitated the mediated role of the diagram between conceptual ideas and their realization.[117] Furthermore, the diagram acts as a mediator between the exploration of the problem and the solution of the space.

[117] The mediating role of the diagram between problem structuring and the problem is an issue also in Fehmi Doğan's thesis. Fehmi Doğan, "The role of conceptual diagrams in the architectural design process: Case studies of the First Unitarian Church by Louis Kahn, the Staatsgalerie by Stirling and Wilford Associates, and the Jewish Museum by Daniel Libeskind" (Ph.D. Dissertation, Georgia Institute of Technology, 2003).

CHAPTER 4

MASTER PLAN FOR ARNHEM CENTRAL STATION, NETHERLANDS 1996-1998

4.1 Context and Motion Studies

Program for the master plan of the Arnhem station area consists of transfer hall, bus terminal, underground car parking, bicycle storage, railway platforms, office buildings, and shops. The construction started with the car park, the bus terminals (1998-2002) and the transfer hall (1998-2010). During these phases also the construction of the offices started (2000-2005). It continued with the construction of railway platforms (2006-2011) which are still under construction with the transfer halls.[118]

The project has concentrated 190.000 m^2 of mixed-use building area on a 40.000m2 site. Six different transport systems that provide the transfer of 55.000 travelers from one system to another per week and 110.000 transfers per day will converge on the station area.[119]

The station area will fulfill a central role in people's daily local or regional travel, and the planned underground parking facility will form the most important entrance to the Arnhem city for those arriving by car. By locating this demanding program on a small area, the need for multiple layered space has occurred. This has led to a

[118] UN Studio, http://www.unstudio.com. (last accessed in August 2010).

[119] Ibid.

unique structural design and vertical transport solution commissioned by the clients, the Ministery of Housing, Planning and Environment the Ministry of Water - and Traffic Management and the City of Arnhem.[120]

Being a merging point of passengers, commercial and social interchanges, the Arnhem Central Project defines an infrastructural organization guided by the search for overlapping areas of shared parameters and common values where one layer of landscape falls into another one.[121] Indicating that the pedestrian movement is the common element that combines all the programs, van Berkel emphasizes that the project was conceptualized on the basis of "movement studies" which were involved in the redevelopment of the location. The intersection of the traffic systems has been reduced to a minimum to optimize pedestrian accessibility to all facilities. The existing height differences in the location have been used to bring all transport systems and facilities together with the movement studies:

> The analysis of the types of movement on location includes the directions of the various trajectories, their prominence in relation to other forms of transportation on the site, duration, links to different programmes, and interconnections.[122]

With motion studies for each of these various trajectories, "a landscape of interrelated movements" has been generated (Figure 32-33). The station area has emerged from these movements that created a system of shortcuts between use and functions (Figure 34). The movements form the "holes in landscape" which generated the folds in the structure. The position of the folds in this landscape has been modified through the "differences in height, pedestrian connections, sight lines

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[120] M. de Boer, J.L. Coenders, P. Moerland, S. Hofman & J.C. Paul, "NSP Arnhem Central Transfer hall," *Arup, Amsterdam,* The Netherlands Taylor & Francis Group, London 2008.

[121] Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation" *Any Magazine,* No. 23 (1998): 22.

[122] Ben Van Berkel and Caroline Bos, *Move-3* (Amsterdam: UN Studio & Goose Press, 1999), 144.

and density surveys."[123] Thus, organization for the masterplan of the Arnhem Station area comprises of different levels that interconnect and give access to trains, taxis, bikes, buses, parking, pedestrian movements, office spaces and the town centre. Overlapping transportation systems and interrelated movements, finally, have demanded the introduction of a diagram that contains a structure for all possible connections; in van Berkel words: "a diagram that encapsulates and advances the technical/spatial organization."[124]

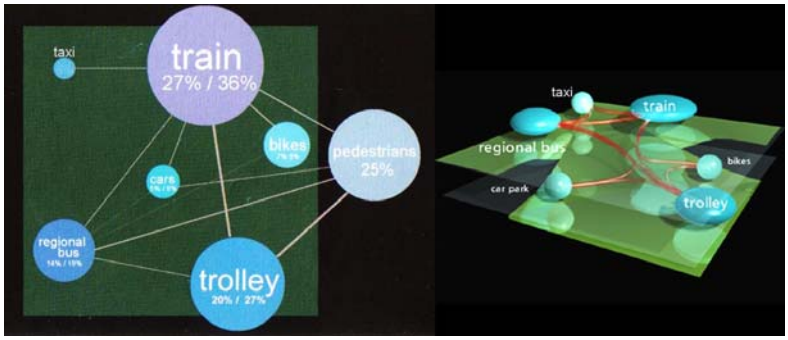

Figure 32: Transfer percentages and interconnections for the masterplan of Arnhem Station.
Ben van Berkel and Caroline Bos, *Move*, Vol.3-Effects (UN Studio & Goose Press, 1999), 163.

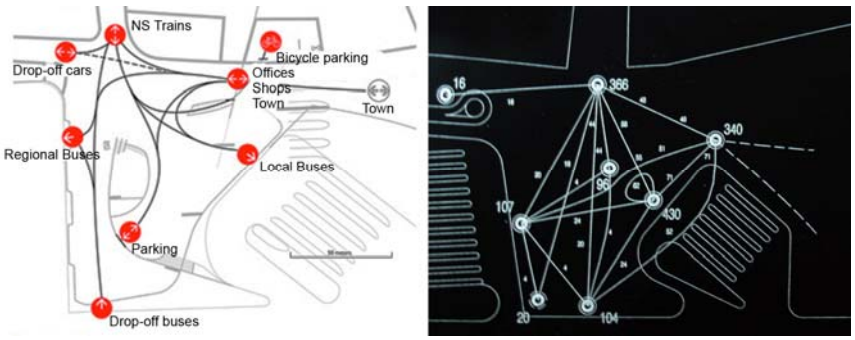

Figure 33: Interrelated movement studies.
(Left) http://www.mijksenaar.com/projects-quicktour/40-arnhem_central_station.html (Last accessed July 2010), (right) Ben van Berkel and Caroline Bos, Move, Vol.3-Effects (UN Studio & Goose Press, 1999), 149.

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[123] Ibid.

[124] Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation" *Any Magazine,* No. 23 (1998): 22.

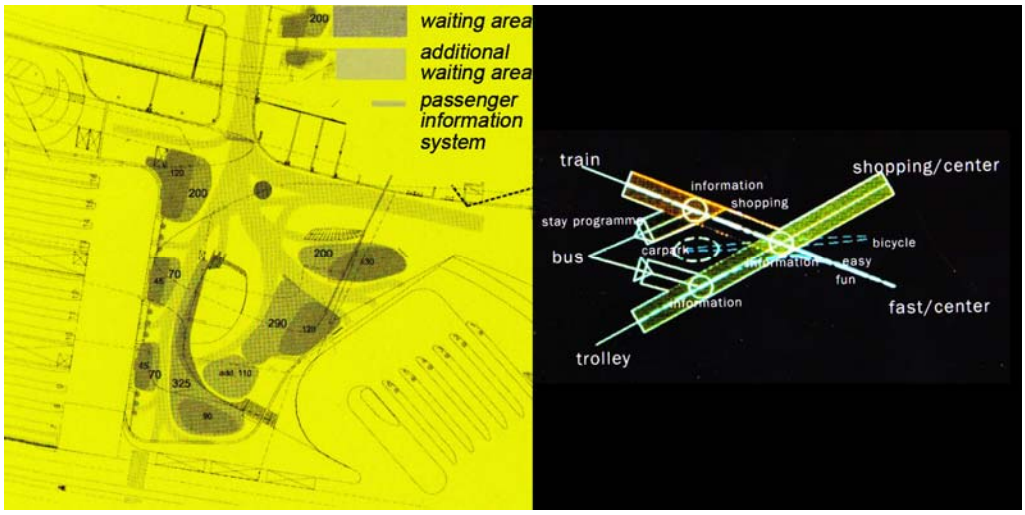

Figure 34: Waiting time and program related surveys.

Ben van Berkel and Caroline Bos, *Move*, Vol.3-Effects (UN Studio & Goose Press, 1999), 152-154.

4.2 Introduction of the Klein bottle diagram as a Generative Design Tool

Being a topological variant of the Möbius Strip, Klein bottle is a non-orientable surface without inner or outer sides (Figure 35). The difference between these structures is the property of boundaries. The Möbius Strip is a two-dimensional surface with boundary, whereas, the Klein Bottle has no boundary. When studying the Möbius Strip or the Klein Bottle, orientability and one-sidedness are important. If a surface is one-sided, it means that you can walk along the surface and reach both sides of each point of the surface.

This non-orientable and one-sidedness quality of the Klein Bottle has provided the structure of the possible connections of relations that were necessary for the transformations in the Arnhem Central project.

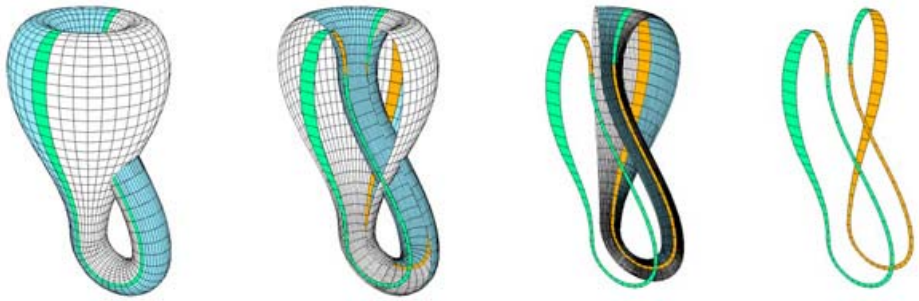

Figure 35: Klein Bottle as the three dimensional variant of a Möbius Strip.

Imaging maths - Inside the Klein bottle,
http://plus.maths.org/issue26/features/mathart/index.html#Build (Last accesed July 2010).

4.3 Evolution of the Diagram throughout the Design Process of Arnhem Central Station

The station area begins to emerge from the motion studies of "interrelated movements." They provide a bridge between programs and possible connections of transportation. This topology of relations demands an introduction of a diagram after a year into the project.[125] In order to be able to abstract the information of relations a Klein bottle diagram is introduced into the design process as a generator of spatial, structural and technical organization (Figure 36). Indicating that the selection and introduction of the diagram was not "serendipitous," van Berkel defines the introduction of it to their design process as "search for a new way of understanding the station area." Starting with the exploration of mathematical knots, Klein bottle diagram was integrated into the design framing the idea that "landscape with holes could also be perceived as knot of planes." Multi-layered structure of the station area could be connected by a diagram which could respond to the demands of motion-based relations. As an infrastructural element it would

[125] Ibid.

stay consistent throughout the spatial transformation - "from being a surface to a hole and back again." [126]

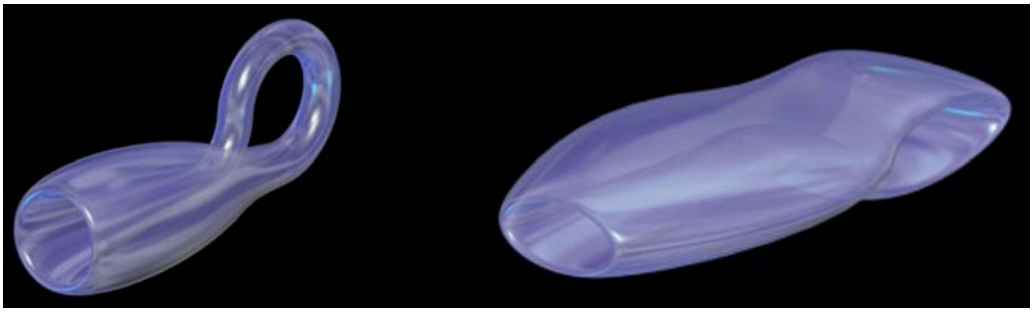

Figure 36: Klein bottle and the diagram for the Masterplan of Arnhem Station

Aaron Betsky, *UN Studio-The Floating Space* (Taschen, 2007), 12.

However, Kari Jormakka criticizes also the translation of the Klein bottle diagram to the design process of Arnhem Central Project in terms of the same problems that occur in the Möbius House Project. Implying the similarity to the Möbius Strip, Jormakka asserts that the Klein Bottle diagram can only exist in four dimensions because of the surface that has to pass through itself without a hole in the Klein Bottle diagram. Criticizing the possibility of the translation of the four dimensional quality of the diagram into one challenging system, he indicates the lack of topological transformation of the diagram architecturally in the translation to the project content, such as the landscape of interrelated movements. He indicates the missing quality of diagrammatic qualities in Arnhem Central Project:

> ....the fundamental geometrical qualities of the topological diagram are necessarily lost in the architectural translation that reproduces the contingent morphology of the model. As a result, the use of the diagram in the first place can only be justified in metaphorical terms, as a form of representation.[127]

[126] Ibid.

[127] Kari Jormakka, *Genius Locomotion* (Vienna: Edition Selene, 2005), 179.

Contrarily, van Berkel asserts that he has made both a pragmatic and diagrammatic use of the Klein bottle diagram as an infrastructural element, as it aided to connect the different parts of the program and generate a whole structure:

> As a concept, the Klein bottle has come about us a result of studies of shared, interactive, local conditions. As a diagram, the Klein bottle becomes an actor in the interactive process as it begins to evoke new, more specific meanings at, for instance, structural and spatial levels.[128]

By introduction of the Klein Bottle Diagram into the design process relations have been structured to form the parameters of the project. The diagram has transformed and inevitably led the generation of the new relations between use-functions and spatial organizations. It has served as a "reference for the spatial transformation of the surface into a whole."[129] The application of the diagram has realizes the spatial integration of the area into a one-terminal concept.

Besides, the integration of the diagram has enabled to generate new possible structures that were formed with the organization of the project. "Structural Twists" and V- Geometries" have been used to define a continuity of the surface and a constructive stability.[130] The structural twists have been designed to help pedestrians to find and choose their destination. They operate as a routing device (Figure 37). This sense of orientation is enhanced by the penetration of light, such as the entrances to the station and to the offices. The twisted concrete elements with a double curvature have also enabled to handle the forty-meter span of the curved

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[128] Ben Van Berkel and Caroline Bos, "Diagrams, Interactive Instruments in Operation" *Any Magazine,* No. 23 (1998): 22.

[129] Ben van Berkel and Carolie Bos, *UN Studio UN Fold* (Rotterdam: Nai Publishers, 2002), 37.

[130] Ibid.

roof.[131] These structural points provide a continuous surface between roof and floor. Parts of the structure are supported by walls on the position of the V-geometries in the parking garage (Figure 38).

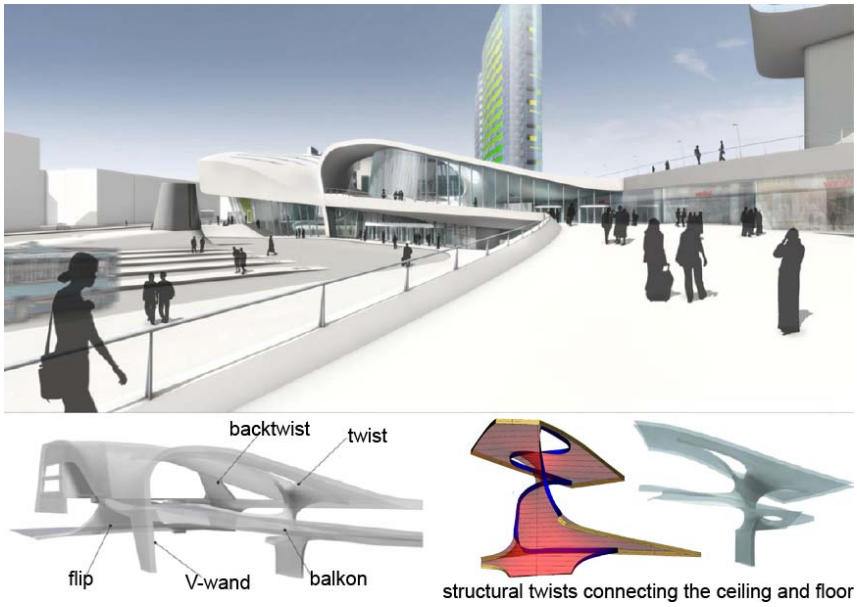

Figure 37: Transfer hall and the structural twists

M. de Boer, J.L. Coenders, P. Moerland, S. Hofman & J.C. Paul, "NSP Arnhem Central Transfer hall," *Arup, Amsterdam,* Taylor & Francis Group, London 2008.

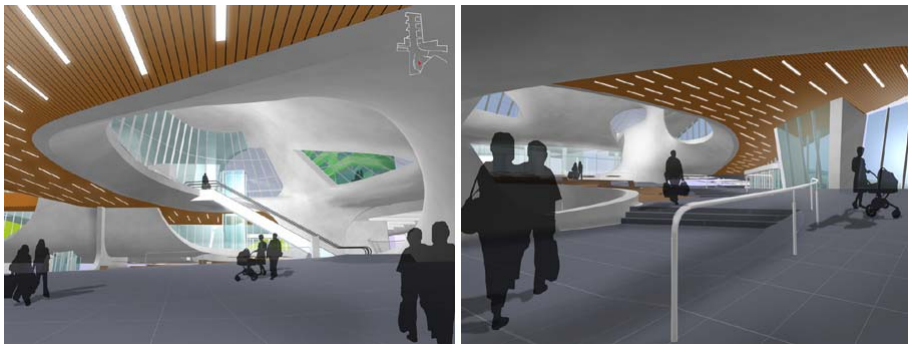

Figure 38: The structural twists from interior.

UN Studio, http://www.unstudio.com. (Last accessed in August 2010).

[131] *L'Architecture d'Aujourd' hui*. "Un Studio/ Ben van Berkel and Caroline Bos." No.321, (March 1999): 60.

The V-shaped shafts integrate functional, constructional, and technical components of the station. Also called as V-collectors that provide vertical public accessibility, they function for integration of office, public space and parking layers into one-system (Figure 39-40). The long V-walls become a "collector" of people, natural light, ventilation, circulation zones, merging the offices with the car park. The vertical integration of the program has been made possible through the simple diagram of the V-walls.

These models of "structural twists" and "V- walls" that have been generated from a diagram, "Klein Bottle," act as devices for organization of the program and construction (Figure 41). The construction phases are also structured by the diagram that has been defined at the initial phases of the project, in the engineering office of Arup's "[it is] defined by custom-built geometrical software tools which translate van Berkel's diagram into a controllable structural model analyzed by parameters."[132] The design phases have been aided by parametric design tools which were able to model the complex non-linear behavior of the concrete double-curved structure. Consequently, it can be asserted that the diagram was not only used to generate the design ideas, but also to structure the construction phases of the design, from conceptualization of the ideas to their translation into the built form (Figure 42-43-44).

[132] M. de Boer, J.L. Coenders, P. Moerland, S. Hofman & J.C. Paul, "NSP Arnhem Central Transfer hall," *Arup, Amsterdam,* Taylor & Francis Group, London 2008.

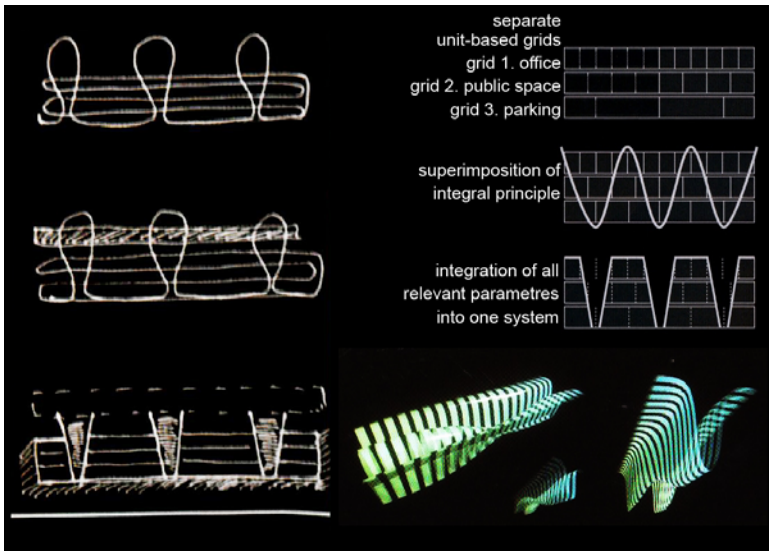

Figure 39: Evolution of the V-Model idea.

(left) *L'Architecture d'Aujourd' hui*. "Un Studio/ Ben van Berkel and Caroline Bos." No.321, (March 1999): 61. (right) Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006), 271-273.

Figure 40: Interrelation of office, public space and parking layers.

L'Architecture d'Aujourd' hui. "Un Studio/ Ben van Berkel and Caroline Bos," No.321, (March 1999): 61.

Figure 41: The V-walls that collect people, natural light, ventilation, circulation zones, merging the offices with the car park.

http://design-daily.com/2010/04/arnhem-central-terminal-by-unstudio/ (last accessed in July 2010).

Figure 42: Elevation from Transfer hall

UN Studio, http://www.unstudio.com. (last accessed in August 2010).

Figure 43: Elevation from railway platforms.

UN Studio, http://www.unstudio.com. (last accessed in August 2010).

Figure 44: The site under construction

Photo taken by the author of the thesis. (April 2009)

4.4 Discussion

The “Klein Bottle” diagram has actively participated in the process where it has guided the spatial, structural and technical interpretation. The diagram has also become a tool for mapping and overlaying more information. Pedestrian movements, transport systems, light, construction and the distribution of the program have been fused into one continuous landscape. That has helped to implement organizations dealing with large influxes of people moving around a system.

As opposed to the Möbius House project in which the diagram has been instrumentalized in the process as a form of representation, in the Arnhem Central Project the Klein Bottle diagram cannot be read as a pure geometrical image. It triggers to generate new possible structures that were formed with the organization of the project, such as “Structural Twists” and V- Geometries” that have been used to define a continuity of the surface of the design.

The diagram is perceived as a conceptual image of the project that collects all different structural and spatial levels and realizes the spatial integration of the area into one terminal concept. The diagram here acts as a tool that generates novel relationships and meanings in technical and spatial organizations by structuring the solution for the interconnection of the trains, taxis, bikes, buses and pedestrian movements.

The parametric design strategies that have been provided by the topological qualities and relations of the diagram have aided to structure the construction phases as well. The identification of the design phases generated by a diagram provides an organization through a terminal concept and defines a whole system. As a mediator oscillating between concept to realization, it provides new and interactive meanings. This potential of generation as an activator in the design process triggers

constructions conceptualized, formed and transformed interactively. Thus, the diagram is seen to have proliferated design ideas and has evoked new insights into the process in the master plan studies for the station area of Arnhem.

CHAPTER 5

MERCEDES BENZ MUSEUM, GERMANY, 2001-2006

5.1 Context and the Program

The design process for the Mercedes Benz Museum has started with a competition conducted by the Board of Management of Daimler-Chrysler AG in 2001. The key assignment of the competition was to design a museum building and the surrounding open-air grounds located near the Mercedes-Benz Untertürkheim factory on the fringes of Stuttgart. The conceptualization, realization and operation process lasted from 2003 to 2006.[133]

The site of the museum is a part of the industrial area close to the motorway. In order to be able to deal with the problematic area, Ben van Berkel has proposed three key elements. First, creating a huge raised platform 5 meters above the ground to define a landmark for the whole area; second, creating a visual landmark for the traffic coming into the city and relating it with the motorway via a compact tall structure; finally, organizing a structure that is adapted to the exhibition circuits.[134]

The program of the museum contained a car museum for historical collections of Mercedes Benz, shops, restaurants, offices, and auditorium. It is also served as a showroom for the collection of Mercedes- Benz. Being the main program of the

[133] Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 41.

[134] Gandolfi Emiliano. "Mercedes-Benz Museum"-interview with Ben van Berkel" *The Plan* (May 2006): 51-64.

museum building, the exhibition program defined by the client needed to be merged with the other programs for defining a dynamic structure as within a museum format. The need to have two parallel but distinct exhibition circuits engenders to come up with a "double-helix" design idea in which one focused on the collection of Mercedes cars and history, the other on the Mercedes myth with legend collections.

5.2 Introduction of the Trefoil Diagram as a Generative Design Tool

In order to handle the movement and circulation studies for the museum a trefoil diagram was introduced into the design. The structure of the trefoil diagram is a mathematical structure consisting of three overlapping circles. Studies on overlapping circles, have provided the UN Studio to explore the effects of intersecting circles in which the center come into existence with a triangular form (Figure 45).

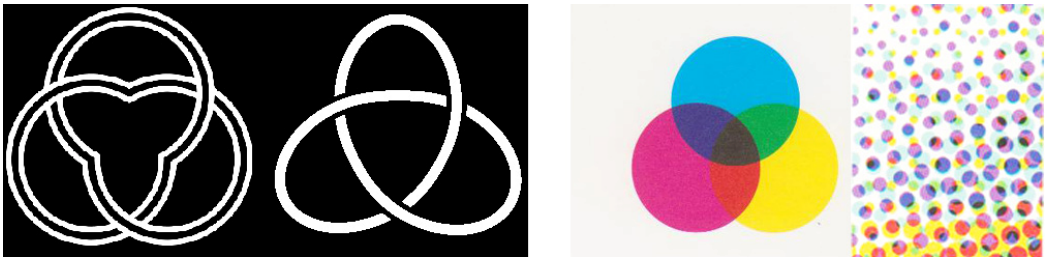

Figure 45: (Left) Trefoil knot, (Right) Conceptual studies exploring the effects of overlapping circles.

Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 54.

Moving from a single line structure, trefoil organization inherits the potential for structure surfaces and volumes both horizontally and vertically. The trefoil knot was transformed to a three dimensional form by introducing height to its two-dimensional linear configuration in order to create structural surfaces (Seifert surfaces) and volumes both horizontally and vertically. Thus, a complicated

circulation system could be generated via organization of the trefoil knot diagram (Figure 46).

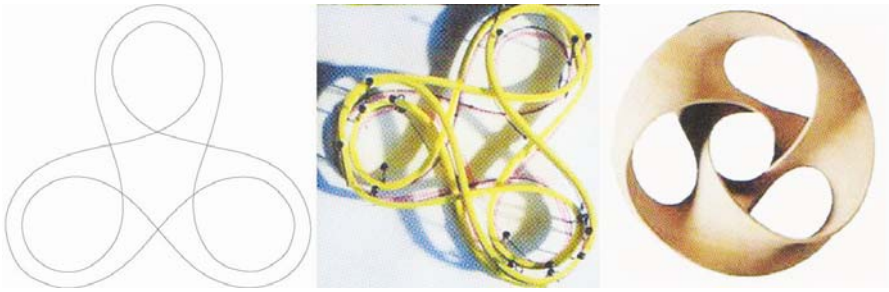

Figure 46: The space exploration process moving from line to surface and volumes.

Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 56-57.

5.3 Evolution of the Diagram throughout the Design Process of Mercedes Benz Museum

The building's program is distributed over the surfaces generated by the trefoil structure. The exhibition program which is used to form the whole structure generates the movement and circulation organizations. With the help of the exhibition circuit studies, the diagram used as an infrastructural tool has enabled the transformation of spatial organizations structured around a circulation (Figure 47).

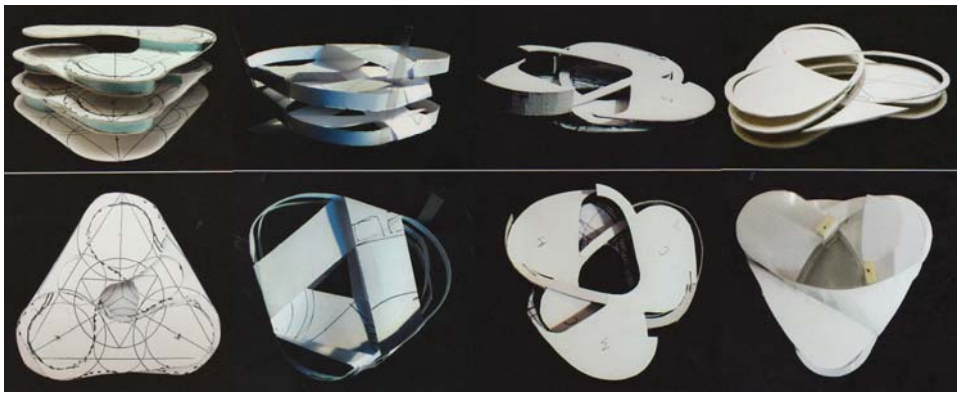

Figure 47: Studies for the three-dimensional spatial organizations of the trefoil.

Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 62-65.

The structural and programmatic organizations have been developed mutually with studies for the three-dimensional spatial organizations of the trefoil. For the organization of the objects of the exhibition program which consist of cars and trucks and legends, the route for the presentation of legend collections was considered to be distinctly separate from the route of cars and trucks. Therefore, a "double-helix" structure that has emerged from the studies with the three-dimensional trefoil diagram has been used. Defined as an infrastructural element by van Berkel, the double-helix "generates not only constructive but also programmatic an infrastructural quality to combine all these architectural ingredients assist together into one structure." [135] The two main trajectories, one being for the car and truck collection and the other consisting of historical displays called the "Legend Rooms", move spirally downwards on the perimeter of the display platforms, intersecting with each other at several points. This intersection would allow the visitors to change their routes (Figure 48).

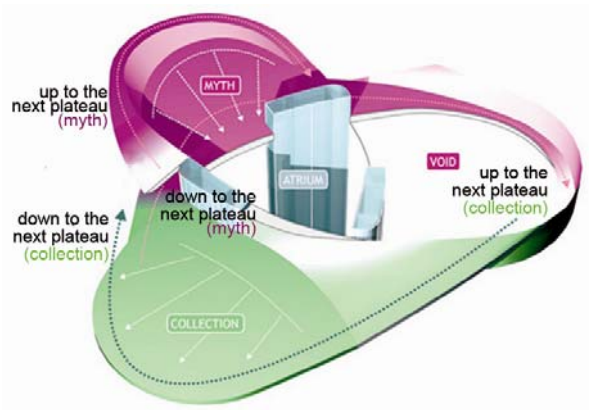

Figure 48: The intersection of the routes allows the change of trajectories.

Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 67.

[135] Ben van Berkel "Envelope Conversation Lecture Series 2010" in Princeton University School of Architecture. March 29, 2010 Video can be found in: http://www.princetonenvelopegroup.com/2010/07/13/ben-van-berkel-lectures-on-the-envelope/ (last accessed in September 2010).

The exhibition trajectory of the museum begins with traveling up through the atrium to the top floor from where the two main paths, the "double-helix," that are ordered chronologically are followed in descent through the building (Figure 49-50). At the top floor starting with a horse the two oldest cars dedicated to the invention of the car are displayed; from here the double-helix begins to turn around a triangular void, producing eight platforms which generate spaces of varying heights, and thus, a dynamic exhibition space. The trefoil structures the visitor's movements as through the exhibition spaces (Figure 51). Referring to the constructive role of the trefoil diagram that has generated the double helix concept, van Berkel states that:

> It is spatially complex concept, which is never openly manifest. The trefoil is not visible in the museum; it is purely a constructive model that generates an enormous amount of freedom.[136]

The organization of the circulation proposes an individual wayfinding, orientation, and "a rational framework, which the visitor is free to follow or to deviate from when attracted by a specific display or program feature."[137] Beside the loose system between the two circuits, they are also needed to be defined with a clear distinction between two galleries. The Collection gallery with cars and trucks are lit by natural light from panoramic windows that are structured by the "tetrapod columns" whereas on the Legend gallery the lighting is artificial. Thus, the diagram integrated into design with its potentials for create closeness and openness of the spatial organization.

Consequently, this trefoil diagram generates spatial constellations, enabling a wide range of options, shortcuts, enclosed and open spaces, and the potential for

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[136] Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 53.

[137] Gandolfi Emiliano. "Mercedes-Benz Museum"-interview with Ben van Berkel" *The Plan* (May 2006): 51.

continuity and cross-references in the various displays. Ben van Berkel states by referring to this generative role of the diagram:

> We look for something beyond the form, something that creates the form and lends it its proportions. […] By using the strong diagram which is full of potential to generate new meanings, we were able to organise ideas of infrastructure, exhibition spaces, programme and even structure.[138]

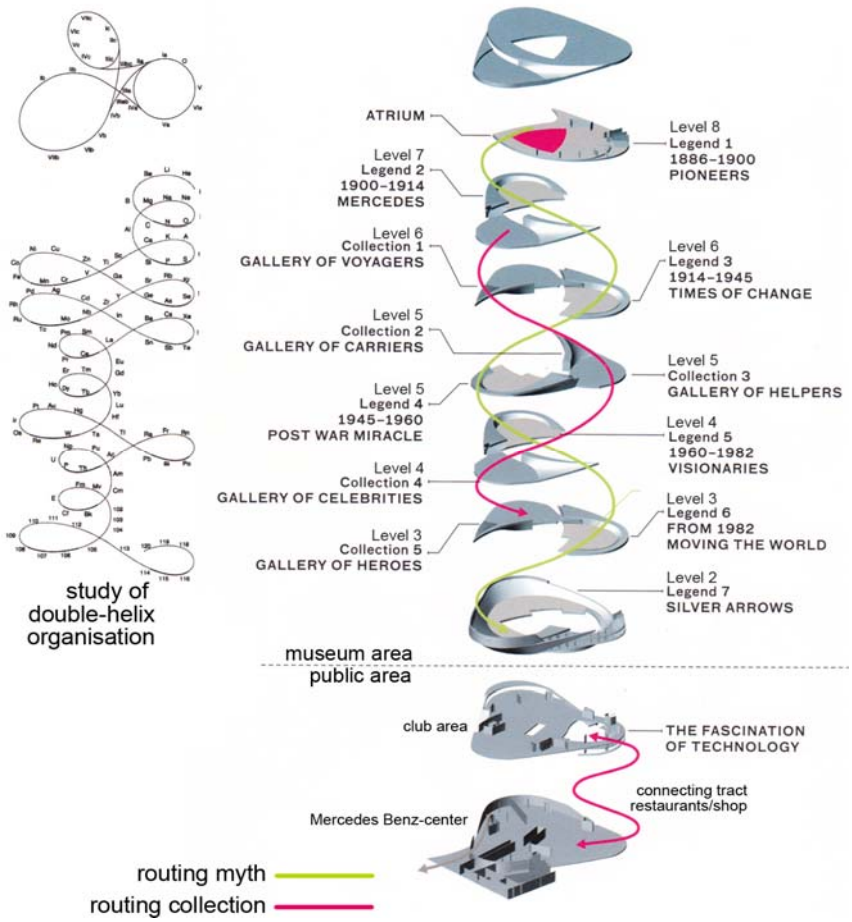

Figure 49: Double-helix organization of Collection and Legend routes descend through the building.
Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 71 and 308.

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[138] Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 53.

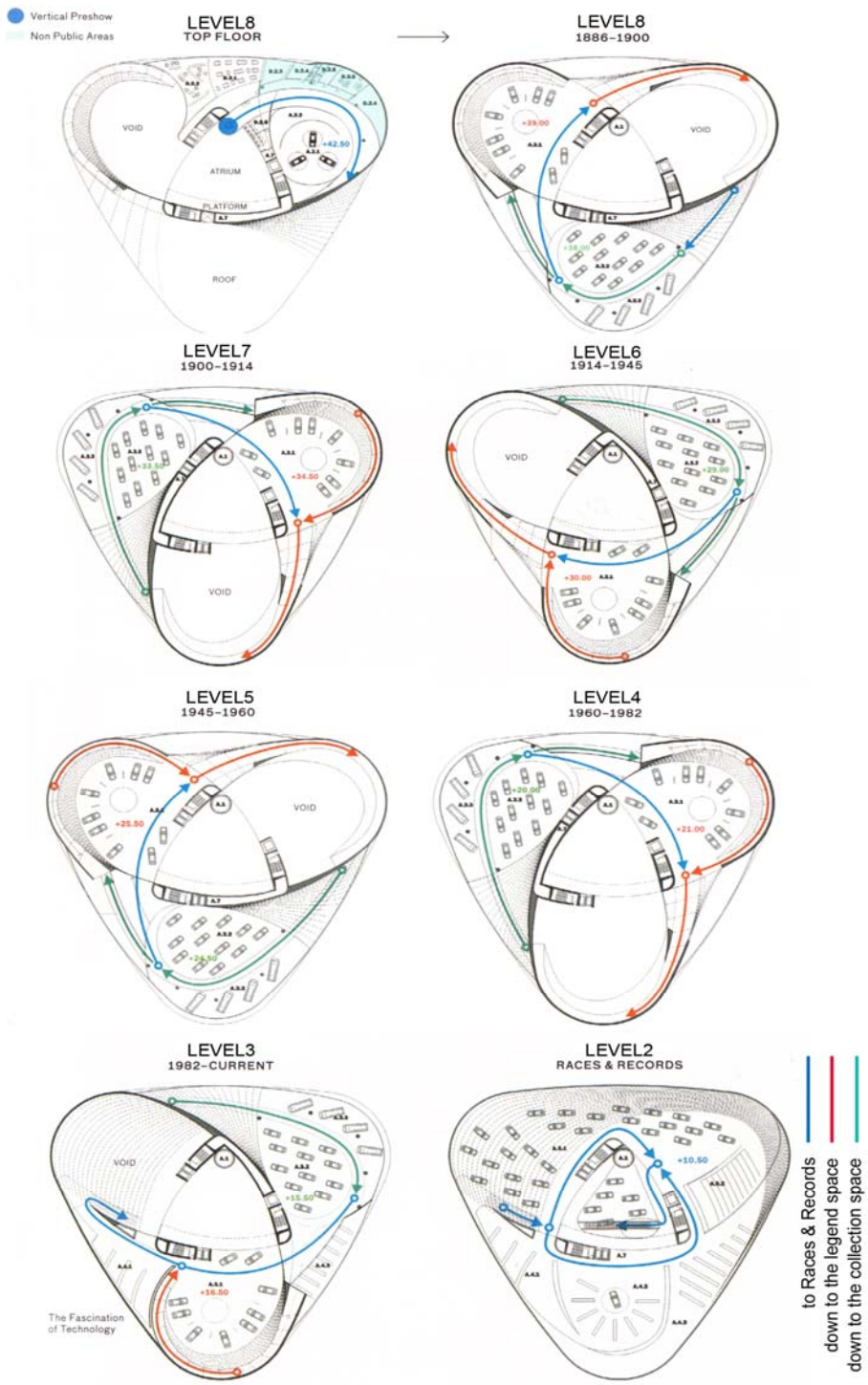

Figure 50: Level plans with the Collection and Legend trajectories.

Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 74-75.

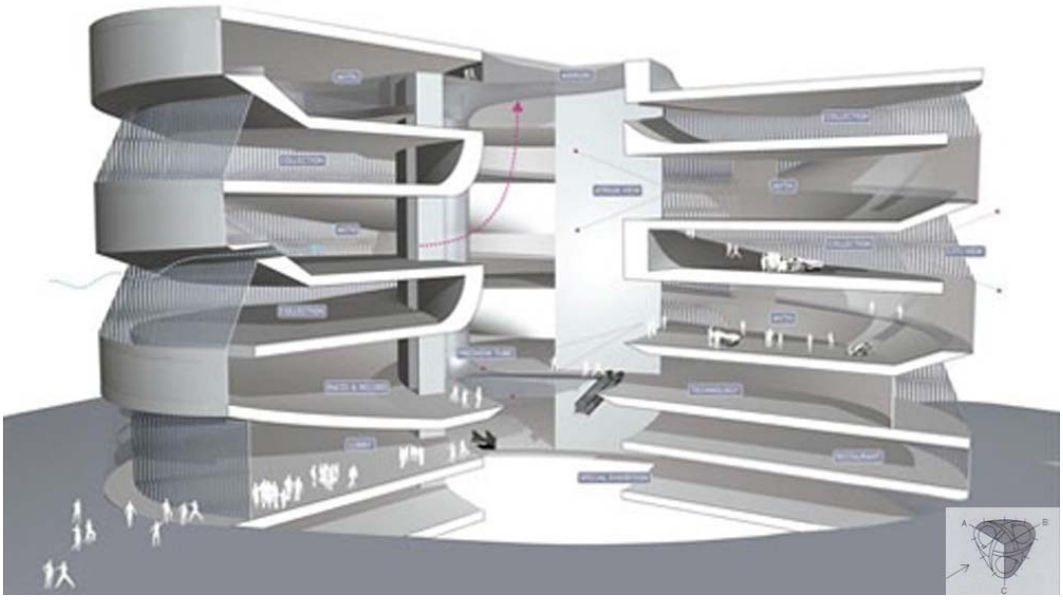

Figure 51: Section perspective showing exhibition areas and circulation.

Aaron Betsky, *UN Studio: The Floating Space.* (Taschen Publishing 2007), 72.

Moreover, van Berkel indicates that "the diagram is used in the project to structure a consistency in spatial organization, in the process and in the construction phases."[139] The challenge of constructing a double-helix as a self-standing structure in the design process of the museum has made the integration of parametric design and production techniques obligatory. The diagram has structured the studies on parametrical inputs provided by a single structure.[140] After the major axes and dimensions have been fixed on the trefoil diagram, rest of the geometry has been configured resulting in a compatible parametrical model (Figure 52).

[139] Ibid.

[140] The parametric design model was managed by an external specialist office "Design to Production" team in Germany. See http://www.designtoproduction.ch/ (last accessed July 2010).

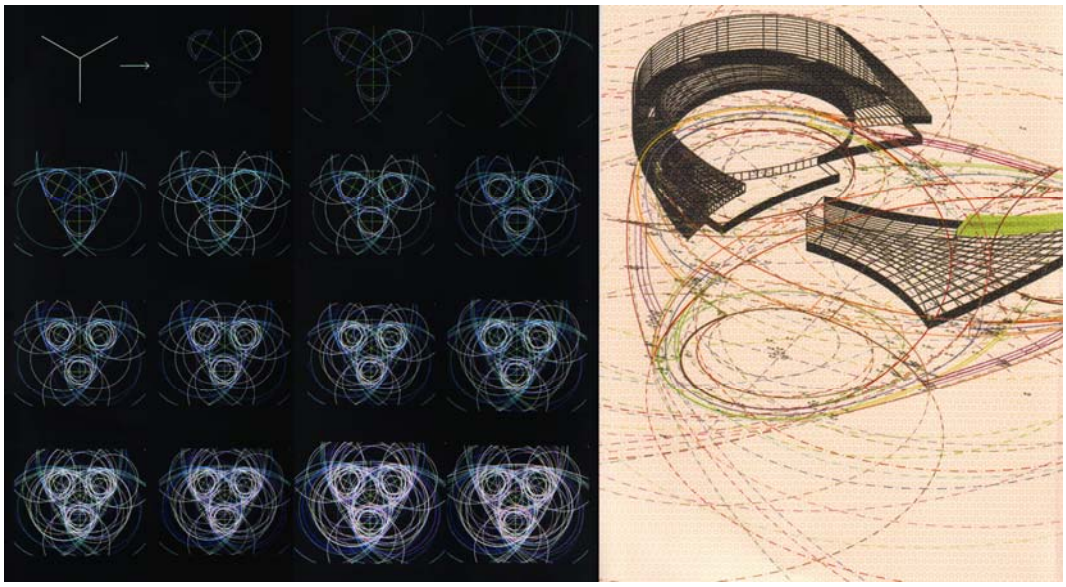

Figure 52: Parametric modeling of Mercedes Benz Museum

Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 82 and 88-89.

Study with parametric design tools has enabled continuous data inputs and removals which have been automatically synchronized in the design process. Managing the design process with the parameters has provided the design to proceed in parallel with the actual building. The problematic of working with several teams of experts who were responsible from lighting to architectural engineering, has been overcome with the "integration of a single model with which all teams are working on it."[141] Any modification on the basic model could affect all aspects of construction. An alteration in the width or height anywhere in construction could require substitution in the layers, interacting with all other inputs of the building, such as the inputs defined for sheeting to the shutters, glass panels to claddings. Studying with one model defined with three different types of software, UN Studio has been able to get

[141] Gandolfi Emiliano. "Mercedes-Benz Museum"-interview with Ben van Berkel" *The Plan* (May 2006): 55.

interactive updates of the whole system down to the last detail, which is called "digital sustainability" by van Berkel.[142]

Defining the building as their manifesto, van Berkel sees the design strategies of the museum as their declaration of integrated building systems (Figure 53-54-55). According to Ben van Berkel, "The Mercedes-Benz Museum sets up an interface for a series of radical spatial principles in order to create a completely new typology."[143] Working with engineers, graphic designers, artists and more than 50 teams has provided a multi-disciplinary study method which is compatible with the "United Network" co-operational system of UN Studio.

Excessive numbers of aspects are involved in the design process of the Mercedes Benz Museum, such as, the structural system, project management, materialization, lighting, patterns, cladding, interior and landscape design, vertical circulation systems, etc. However, due to the purposes of this thesis, the emergence and utilization of the diagram throughout the design process of the museum is focused on. Transformations in its utilization to generate novel design inputs are the main motivation for this focus.

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[142] See the subtitle "2.2.3. Introduction of Computational Design Tools." for the detailed definition of "digital sustainability" identified by Ben van Berkel."

[143] Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006), 34.

Figure 53:Mercedes Benz Museum.

Photo taken by the author of the thesis (May 2009).

Figure 54: Photo from Layer 5, Legends 1945-1960 Post War Miracle Gallery.

http://www.flickr.com/photos/34988616@N07/4470003723/ (last accessed in August 2010).

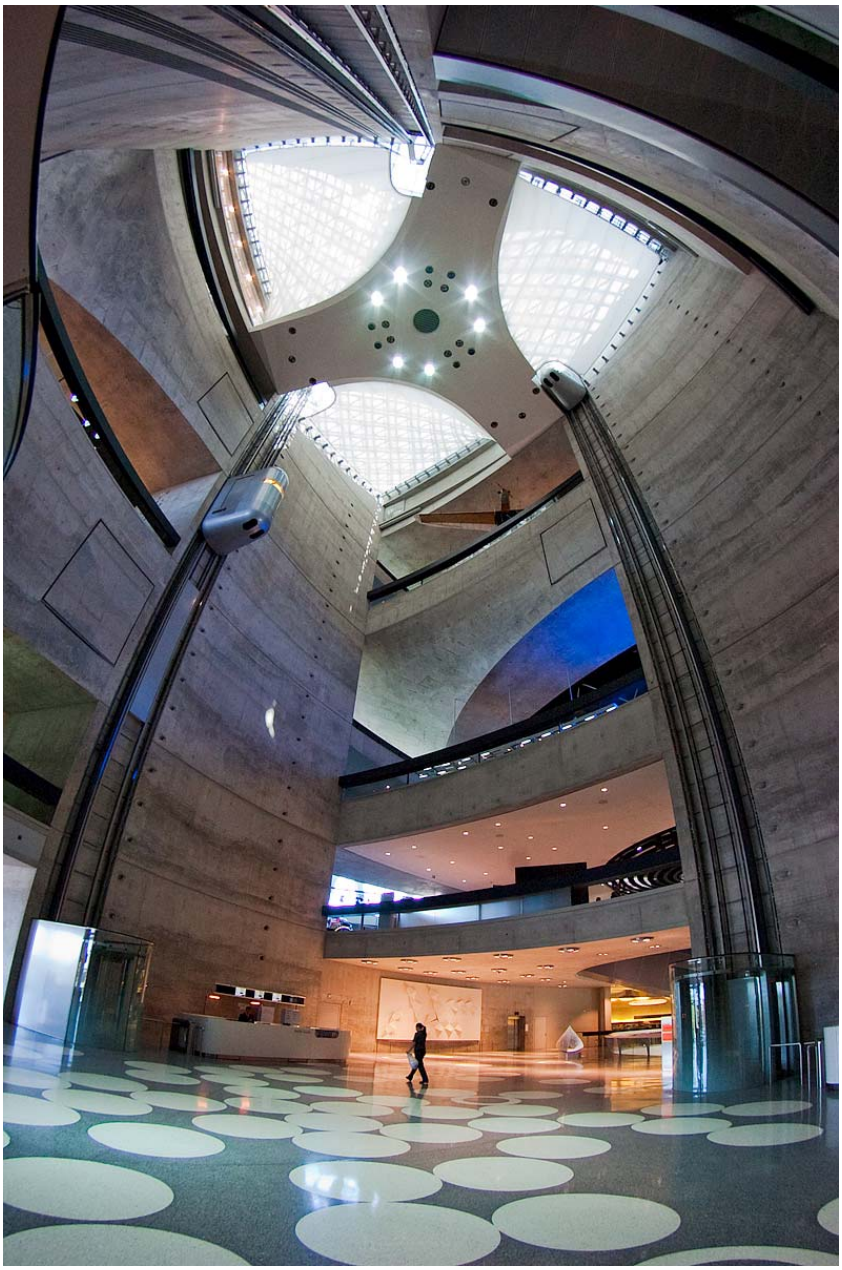


Figure 55: The triangle atrium connecting the layers.

Photo by Volker Wurst

5.4 Discussion

For the museum, the trefoil offers a movement between forms of continuity and cross references, between open and closed spaces, which interweaves the different exhibitions organized by the museum. The visitors move in a continuous movement of shifting orientations generated by the different notions of time that the museum recreates.

The trefoil diagram has allowed the generation of the tools that guided the spatial and structural organizations of the process. In doing so, it has helped to manage the variations between the different levels, to challenge both the symmetry and the flatness of the floors, and to create a wide range of paths and shortcuts without columns. It has provided a map for two intertwining museum circuits which structure the whole concept of the building. The diagram transformed into building has aided implementation of relational organizations dealing with large influxes of people moving around a system. As a proliferator, it has been an infrastructural element that has been responsible for a generative process from concept to its realization.

The parametric design methods that have been based on one single model derived from the trefoil diagram, has aided to structure the construction phases as well. The model defined with parametric inputs has helped to work on a condensed information system and to structure the whole design process that can be updated automatically. This interactive model has enabled a manageable design process open to modifications.

However, it can be asserted that definition of the design process from concept to the actual building by the diagram is interrupted. Although, computer-aided design tools help to phasing the construction layers by the diagram introduced, the diagram

cannot construct the whole process. The introduction of the diagram and the translation of it into the architectural final outcome still need to be clarified.

It can be considered that a single diagram responsible for the generation of novel design ideas can trigger the gathering of all the project requirements such as concept, program, structural and formal aspects, and construction details, into one structure, however, the translation of the diagram into the architectural realization can be asserted as inadequate to define the whole process.

CHAPTER 6

CONCLUSION

This thesis introduces a question for inquiry and explorations: How are diagrams utilized in the architectural design process as generative design tools? With regard to the question the thesis searched for the possibilities of design processes developed and manipulated not through analytical use of diagrams that represents the already established relationships, but through their generative use that is responsible for the proliferation of ideas for novel design concepts.

The thesis examined the diagrams in terms of the way they are utilized and operated in architectural design from conceptualization to building. Taking the shift in the use of diagrams from explanatory and analytic to generative as a starting point, the generative roles of diagrams as design tools for proliferating possible conceptual, organizational and structural principles for the design process are explored. In this respect potency of diagrams responsible for the generation of new relationships are argued.

The thesis claims that with their potency as generative design tools, diagrams differentiate themselves from the analytical use of diagrams in that they do not suggest direct formal or relational implications. Since they are abstractions away from materiality, they function as instrumental devices that proliferate design ideas and trigger focusing on design process rather than concentrating on the formal outcome. The shift from representational concerns toward the generative processes of open systems provided by the diagrams promotes a turn towards generative and

experimental design methodologies. Diagrams operate as “abstract machines” for proliferation while acting a generative role by incorporating relations and forces. They unfold complexity by being generative rather than reductive.

Diagrammatic design process overcomes the fixed formal expressions of design ideas and becomes open to modifications and interventions required by the relations and forces by affecting different layers. The information embedded into the diagram provides a proliferative and suggestive design process freed form typological concerns of the conventional architectural practices. It can be asserted that the diagrams used as generative design tools aid to define dynamic open-ended and process-oriented design strategies.

Liberated from the formal determinism of the conventional design approach, a conscious delay in the typological fixation of form and visual representation is initiated. While making the design idea independent of formal fixations, the generative use of diagrams also reveals a departure from typological practice. This focus on the generative character of diagrams then gives way to the grounds for topological practices which construct and manage the relationships in the design process more dynamically and trigger novel design ideas liberated from formal determinism. This attention placed on relations rather than form of specified function can be asserted to offer a transformation in the use of diagrams.

The thesis foresees that the generative roles of the diagrams in the design process will be improved by the introduction of computational design tools. The computational tools enable to work with design methods that rely on compatible software for dealing with complex relationships. Thus, these tools introduced via computational design approach facilitate working with multi-layered information that structures the diagram which provides for the modification and interaction of possible relations. With the potency of relations in which information is transferred, interacted and manipulated by defined parameters, the diagram continues to inform

design process from concept to realization. This ability of mapping complex relationships and rendering correlation between concept and the final outcome provides the complex and various interpretations of analysis (such as movement, site, program, circulation analysis) structured in the diagram. It may be asserted that the potency of diagrams in the design process can be advanced by the opportunities that computational design tools introduce.

The diagrams as infrastructural and generative tools are indicated as proliferators to operate in different design processes. A diagram may function to open up new possibilities by taking place in more than one project. The evolution of the diagrams from their emergence to the realization of the actual building in the design process of UN Studio is tried to be shown by using the selected projects in the thesis. Although, they are relevant projects that show the generation of different design processes derived from variations of a single diagram (Möbius Strip-Klein Bottle-Trefoil), there are still parts that remain blurred in the evolution of the diagram in their design process. In spite of these obscure parts, it is tried in the thesis to remain as consistent and clear as UN Studio in defining their projects and design processes. Hereby, the thesis does not only criticize the design process of UN Studio but also makes a self-criticism.

The evolution of the diagrams can be explored in the design process of the projects; however, the introduction of the diagrams still remains obscure as in the introduction of the Klein Bottle diagram to the process of the Arnhem Central Project. Another obscure part which has to be clarified is the role of the diagrams in structuring the process from concept to realization. It can be asserted that the diagram helps to phase the construction by parametrical inputs aided by the computational design tools as in the construction phases of the Mercedes-Benz Museum. However, it has not been possible to define the whole process from the initial phases of the design process to the final outcome. There still remains a gap between the introduction of the diagram into design process and its architectural

translation, such as in the representational aspect of the Möbius Strip in the Möbius House project or abstraction of the Klein Bottle in the Arnhem Central Project.

Therefore, some questions still remains to be clarified: What triggers the introduction of the diagram into the design process except the analysis of contextual or programmatic inputs? Is that a personal or intuitive selection? Can the diagram help define the whole process from concept to realization? These are the questions that still need to be answered; they may open novel research titles for further studies.

Moreover, the potency of the diagrams to structure the whole design process is questioned in reference to the architectural design methodologies of UN Studio in the thesis. In the selected projects the emergence and operation of the diagrams were focused on. The diagrams could act as infrastructural elements that were responsible to create new relational possibilities for each project. The study of these projects showed that different outcomes of distinctly different design processes could be derived from a single diagram. In the Möbius House project, the Möbius Strip has been used as an organizational structure which has integrated the program into the design process both in terms of circulation and structure. The Klein Bottle diagram has been used for mapping and overlaying of the movement studies of Arnhem station area. In the case of Mercedes Benz Museum, the diagram structures the whole process from the exhibition routes to constructional phases by guiding the spatial organizations of the surfaces and volumes. These show the potency of diagrams responsible for generating different design processes.

Although they are different projects at different scales with distinct design processes and formal outcomes, they have shared aspects in terms of the role of the diagram in the process. All of the projects inherit spatial and structural qualities provided by the generic roles of the diagrams. All the program inputs identified by different activities have been condensed into one structure. This structure aids the designer to define the design situation, lay out possible proposals to explore, and open up

potential solutions for the final outcome. Moreover, the diagram mediates between exploration of the problem and the solution of the space. It acts as a mediator that proliferates novel and interactive meaning for the generation of design concepts.

The thesis proposes ways to design with diagrams. However, it is not proposing a design method appropriate for all design conditions and processes. Instead, it proposes that study on diagrams and producing their own diagrams can provide designers the means to structure their design processes. However, this proposal is not for definition of an ideal and universally usable diagram, instead, it is about defining a diagram which should be kept experimental and operative and open to development. [144] The transformation of the Möbius Strip to the Klein Bottle and the trefoil diagram that act to generate, operate and manipulate distinct design process can be asserted as a way of design that is explored elaborately through the three projects presented. This transformability and multi-useability of the diagram in the design process, which is called as "design models" by Ben van Berkel,[145] provides not only for the operation of a diagram for more than one project, but also assignment of various diagrams for a single project. Diagrams may be asserted to enable the architects to find tools to generate solutions for new skills, new ways of imagining and realizing the construction specific for the designer.

The thesis expects to trigger potential future studies that may be based on the explorations and findings of this study. One of the studies would be to further the exploration of the utilization of the diagrams to define other roles that may contribute to frame the design process. These can be repetitive, representational, and conceptual roles as other than the generative and mediator ones. Another study can be a research on the potentials of the topological structures for triggering an architectural design process. Different further study might be the potency of the

[144] Ben van Berkel (UN Studio-Amsterdam), interview with Ben van Berkel conducted by the author of this thesis, September 2009. See Appendix A.

[145] The "design models" are elaborately explored under the subtitle "2.4 From Diagram to Design Models" of this thesis.

computer-aided design tools for diagrams, as parametrically defined mathematical or topological based diagrams. Releasing the possibilities of these diagrams can be concluded with different and complex outcomes for the construction phases as well. The final further study might be the generative role of the diagrams in architectural education in order to promote ways of designing.

BIBLIOGRAPHY

Works Cited

Allen, Stan. "Diagrams Matter." *Diagram Work*, *Any Magazine* 23 (1998): 16-19.

Alexander, Christopher. *Notes on the Synthesis of Form*. Cambridge: Harvard University Press, 1964.

Alexander, Christopher. *A Pattern Language: Towns, Buildings, Construction*. New York: Oxford University Press, 1977.

Alexander, Christopher. *The Timeless Way of Building*. New York: Oxford University Press, 1979.

Betsky, Aaron. *UN Studio: The Floating Space.* Taschen Publishing, 2007.

Blackwell, Alan F. and Yuri Enelhardt, "A Taxonomy of Diagram Taxonomies," in *Proceedings of Thinking with Diagrams 98: Is There a Science of Diagrams?* 60-70 (1998).

Braham, William. "After Typology: The Suffering of Diagrams." *AD: Contemporary Processes in Architecture.* Academy Editions: London, Vol. 70, no. 3, (2000): 9-11.

Boer M. de., J.L. Coenders, P. Moerland, S. Hofman & J.C. Paul, "NSP Arnhem Central Transfer hall." *Arup, Amsterdam,* Taylor & Francis Group, London 2008.

Coxeter, Harold Scott Macdonald. *Non-Euclidean Geometry.* Washington, D.C., Mathematical Association of America, 1998.

Deleuze, Gilles. "The Diagram." In *The Deleuze Reader*, edited by Constantin V. Boundas, 193-200. New York: Columbia University Press, 1993.

Deleuze, Gilles and Felix Guattari. *A Thousand Plateaus: Capitalism and Schizophrenia*. Trans. Brian Massumi. Minneapolis: University of Minnesota Press, 1987.

Deleuze, Gilles. *Foucault.* Minneapolis: University of Minnesota, 1988.

Deleuze, Gilles. *Francis Bacon: The Logic of Sensation*. trans. Daniel W. Smith. Minneapolis: University of Minnesota Press, 2003.

De Landa, Manuel. "Deleuze, Diagrams and the Genesis of Form." *Diagram Work*, *Any Magazine* 23 (1998): 30-34.

Detailtopics. Interview with Ben van Berkel "Digital Sustainability and Spaces That Follow You." http://detailtopics.com/digital-architecture/en/discussion/interview-ben-van-berkel/ Last accessed July 2010.

Di Cristina, Guiseppa. "The Topological Tendency in Architecture." *Science and Architecture.* ed. Guiseppa Di Cristina, 6-13. Wiley Academy, 2001.

Doğan, Fehmi. "The role of conceptual diagrams in the architectural design process: Case studies of the First Unitarian Church by Louis Kahn, the Staatsgalerie by Stirling and Wilford Associates, and the Jewish Museum by Daniel Libeskind." Ph.D. Dissertation, Georgia Institute of Technology, 2003.

Ednie- Brown, Pia. "The Texture of Diagrams: Reasoning on Greg Lynn and Francis Bacon." *Daidalos* 74 (2000): 72-79.

Eisenman, Peter. *Diagram Diaries*. London: Thames & Hudson, 1999.

Eisenman, Peter. "Diagram: An Original Scene of Writing." *Diagram Work*, *Any Magazine* 23 (1998): 27-30.

Emiliano Gandolfi. "Mercedes-Benz Museum." *The Plan* (May 2006): 51-64.

Emmons, Paul Frederick. "The Image of Function: Architectural Diagrams in Handbooks and Normative Practices in the Twentieth Century." Ph.D. Dissertation, University of Pennsylvania, 2003.

Francis, George K. *A Topological Picturebook*. Springer, October 24, 2006.

Foucault, Michel. *Discipline and Punish: The Birth of the Prison.* New York: Vintage Books, 1979.

Ivars, Peterson. *Möbius in the Playground*. http://www.sciencenews.org/sn_arc99/5_22_99/mathland.htm Last accessed in May 2010.

James, I.M. *History of Topology.* Amsterdam, New York, 1999.

Jormakka, Kari. *Genius Locomotion,* Vienna: Edition Selene, 2005.

Jormakka, Kari. *Flying Dutchmen: Motion in Architecture.* Basel; Boston; Berlin: Birkhauser, 2002.

Kalfazade, Nihat. "Diagrammatic Potency of the 'Nine Square Grid' in Architectural Design," Master Thesis, Middle East Technical University, 2004.

Knoespel, Kenneth J. "Diagrams as Piloting Devices in the Philosophy of Gilles Deleuze." *Theorie Literature Enseignement - Deleuze-Chantier.* No.19 (Saint-Denis: Presses Universitaires de Vincennes, 2001): 145-165.

Kolarevic, Branko. "Towards Non-Linearity and Indeterminacy in Design." Cognition and Computation in Digital Design. The University of Sydney Faculty of Architecture, Design Computing Cognition'04.

Küçük, Alper. "The Architectural Precedent and the Diagram : A Comparative Analysis of Le Corbusier's Villa Savoye and Rem Koolhasss' Maison a Bordeaux." Ph.D. Dissertation, Middle East Technical University, 2007.

L'Architecture d'Aujourd' hui. "Un Studio/ Ben van Berkel and Caroline Bos." No.321, (March 1999): 43-100.

Lootsma, Bart. "Casa unifamiliare Möbius, 't Gooi, Paesi Bassi/Möbius one-family house, 't Gooi, The Netherlands." *Domus*, Vol:814 (April 1999): 45.

Lowe, Richard K. "Diagrammatic Information: Techniques for Exploring its Mental Representation and Processing." *Information Design Journal* 7-1 (1993): 3-18.

Lynn,Greg and Daniel Birnbaum, "Digital Conversation" in *UN Studio UN Fold* Rotterdam: Nai Publishers, (2002).

Lynn, Greg. "Multiplicitous and Inorganic Bodies." *Assemblage,* No:19 (1992): 32-49.

Maçoro, Engin. "Diagram as a Tool for Creative Process In Architectural Design." Master Thesis, ITU, 2009.

Pai, Hyungmin. "From The Portfolio To The Diagram: Architectural Discourse and the Transformation of the Discipline of Architecture in America, 1918-1943." Ph.D. Dissertation, MIT, 1993.

Pai, Hyungmin. *The Portfolio and the Diagram: Architecture, Discourse, and Modernity in America.* Cambridge, Mass: MIT Pres, 2002.

Pickover, Clifford A. The Möbius Strip: Dr. August Mobius's Marvelous Band in Mathematics, Games, Literature, Technology, and Cosmology. Thunder's Mouth Press, New York, 2006.

Sevaldson, Birger. "Dynamic Generative Diagrams." ECAAD Weimar 2000.

Sevaldson, Birger. Developing Digital DesignTechniques. Investigations on Creative Design Computing, Ph.D. Dissertation, Oslo School of Architecture, 2005.

Sevaldson, Birger. "Research on Digital Design Strategies." Oslo School of Architecture, 1999.

Somol, Robert, E. "The Diagrams of Matter," *Diagram Work*, *Any Magazine* 23 (1998): 23-27.

Somol, Robert. E. "Dummy Text or the Diagrammatic Basis of Contemporary Architecture." *Diagram Diaries,* 6-25. New York: Universe Publishing, 1999.

Thackara, John. "Deep Planning." *Domus* 852 (Oct. 2002): 100-105.

UN Studio, http://www.unstudio.com. Last accessed in August 2010.

van Berkel, Ben "interview with Ben van Berkel" conducted by the author of this thesis, September 2009.

van Berkel, Ben and Caroline Bos, *Move*, Vol.1-Imagination, Vol.2-Techniques, Vol.3-Effects. UN Studio & Goose Press, 1999.

van Berkel, Ben and Caroline Bos. "Diagrams-Interactive Instruments in Operation." *Diagram Work*, *Any Magazine* 23 (1998): 19-23.

van Berkel, Ben and Caroline Bos. "Untitled Editorial." *Diagram Work*, *Any Magazine* 23 (1998): 15.

van Berkel, Ben and Caroline Bos. *UN Studio: UNFOLD.* Rotterdam: NAi Publishers, 2002.

van Berkel, Ben and Caroline Bos. *Mobile Forces= Mobile Kräfte*. Berlin: Ernst & Sohn, 1994.

van Berkel, Ben and Caroline Bos. "Untitled Editorial." *El Croquis*, (May 1995).

van Berkel, Ben and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* Rizzoli, 2006.

Van Berkel, Caroline Bos. *Buy me a Mercedes Benz-The Book of the Museum.* Actar, December 2006.

Vidler, Anthony. "Diagrams of Diagrams: Architectural Abstraction and Modern Representation." *Representations* 72 (Fall 2000): 1-20.

Vidler, Anthony. "Diagrams of Utopia." *Daidalos 74* (2000): 6-13.

Yardımcı, Baran. "Diagram as an Architectural Design Tool." Master Thesis, ITU, 2007.

Yazgan, Kerem. "Designography of Architecture." Ph.D. diss., METU, 2003.

____ "Ideogram to Diagram" Interview with Ben van Berkel. Ouaderns Espirales Spirals No:222. Barcelona : Bosch, Casa Editorial (August 1999).

Selected Bibliography

Allen, Stan. *Points + Lines, Diagrams and Projects For The City*. (Princeton Architectural Pres, 1999).

Allen, Stan. "From Object to Field." *Architectural Design* 67 no 5/6 (may/June 1997): 24-31.

Allen, Stan. *Practice, Architecture, Technique and Representation*. London: Routledge, 2000.

Argan, Carlo Guilio. "On the Typology of Architecture." Translated by Joseph Rykwert, *Architectural Design* (December, 1963): 564-565.

Bridges, Alan H. "Computer-Aided Design or Computers and Design." *Computers in Architecture.* ed. Francois Penz, 41-52. Hong Kong: Longman, 1992.

Clayton, M.J. "Diagramming Aesthetics: Modernism and Architecture in the 21st century." In *Theory and Application of Diagrams: First International Conference, Diagrams 2000, Edinburgh, Scotland, UK, September 2000: Proceedings* 257-270 New York: Springer, 2000.

Coenen, Jo, Piet Vollaard. *Architecture in the Netherlands: Yearbook 2001-2002.* Revised edition. Rotterdam: NAi Publishers, 2002.

De Landa, Manuel. "Deleuze and the Use of the Genetic Algorithm in Architecture." http://www.cddc.vt.edu/host/delanda/pages/algorithm.htm
Last accessed July 2009.

Do, Ellen Yi-Luen and Mark D. Gross. "Reasoning About Cases with Diagrams." In *Proceddings 3rd Congress on Design Computing ASCE*, Anaheim (June 1996).

Do, Ellen Yi-Luen and Mark D. Gross. "Thinking with Diagrams in Architectural Design." *Artificial Inteligence Review* 15 (2001).

Do, Ellen Yi-Luen. "Computability of Design Diagrams: an empirical study of diagram convetions in design." In *Proceedings of CAAD Futures 1997 Conference,* Munich, Germany (August 4-6, 1997), 171-176.

Do, Ellen Yi-Luen. "What's in a Diagram that a Computer Should Understand?." In *CAAD Futures '95*, edited by The Global Design Studio, Tan and Tech, 469-482. National University Sngapore, 1995.

Doğan, Fehmi and Nancy J. Nersessian. "Computational Diagrams: Representing Ideas in Design." In *Diagrammatic Representation and Inference: Second International Conference, Diagrams 2002*, edited by M. Hegarty, B. Meyer, N. Hari Narayanan, 353-355.

Eisenman, Peter. *RE: working Eisenman.* London: Academy Editions, 1993.

Emmons, Paul F. "Embodying Networks: Bubble diagrams and the image of modern organicism." *The Journal of Architecture* (2006): 441-461.

Ervin, Stephen M. "Designing with Diagrams: A Role for Computing in Design Education and Exploration." In *The Electronic Design Studio*, edited by Mc Cullough, 107-122. Cambridge: MIT Press, 1994.

Franck, Oya Atalay. "Mimarlık Diyagramları ve Diyagram Mimarlığı." *Arredamento Mimarlık* 6 (2002): 80-83.

Flegg, H. Graham. *From Geometry to Topology*. New York: Crane, Russak & Co. Inc., 1974.

Graf, Douglas. Diagrams. *Perspecta* Vol 22 (1986): 42-71.

Greaves, Mark. *The Philosophical Status of Diagrams.* Stanford: CSLI Publications, 2003.

Gross, Mark D. "Recognizing and Interpreting Diagrams in Design." In *Advanced Visual Interfaces '94* edited by T. Catarci, Bari, 1994.

Gross, Mark D. "The Electronic Cocktail Napkin- a computational environment for working with design diagrams." *Design Studies* 17 (1996): 53-69.

Herdeg, Klaus. *The Decorated Diagram: Harvard Architecture and the Failure of the Bauhaus Legacy.* Cambridge : The MIT Press, 1983.

Hewitt, Mark. "Representational Forms and Modes of Conception: An Approach to the History of Architectural Drawing." *Journal of Architectural Education.* No: 39 /2, (1985).

Heuvel, Dirk van den. "Generative Dynamics." *L'Architecture D'Aujourd'hui* 344 (January-February 2003).

Howse, J., Molina, F., Shin, S. "On Diagram Tokens and Types." In *Diagrammatic Representation and inference: Second International Conference, Diagrams 2002, Callaway Gardens, GA, USA, April 18-20, 2002: Proceedings* ed. by M. Hegarty, B. Meyer and N. H. Narayanan 146-160 (Berlin New York: Springer, 2002).

Ito, Toyo 'Diagram Architecture', *El Croquis,* 77 (1996): 18-24.

Knoespel, Kenneth J. "Diagrammatic Writing and the Configuration of Space." *Figuring Space: Philosophy, Mathematics, and Physics* (English translation of Les enjeux du mobile: mathematique, physique, philosophie [Paris: Seuil, 1993]), ix-xxiii. Dordrecht: Kluwer Academic Publishers, 2000.

Knoespel, Kenneth J. "Diagrams and the Anthropology of Space." *Philosophica*, Vol.70, (Ghent: Ghent University, 2002): 5-9.

Kolarevic, Branko. "Digital Morphogenesis." *Architecture in the Digital Age: Design and Manufacturing.* ed. Branko Kolarevic. London and New York: Spon Press, 2003.

Kolarevic, Branko. "Digital Praxis: From Digital to Material." ERA Group, http://www.era21.cz/index.asp?page_id=96. Last accessed in July 2009.

Kolarevic, Branko. "Designing and Manufacturing Architecture in the Digital Age." Laboratorio TIPUS, http://www.tipus.uniroma3.it/Master/lezioni/AID/Branko.html. Last accessed in July 2009.

Kühn, Christian. "Diagrams Are Forever: Christopher Alexander's Pattern Language and Notes on the Synthesis of Form." *Daidalos* 69/70, (1998/99): 136-141.

Larkin, Jill. H., and Herbert A. Simon. "Why a Diagram is (sometimes) worth ten thousand words." *Cognitive Science Journal*, 11 (1987): 65-99.

Loootsma, Bart. *SuperDutch : New Architecture in the Netherlands*. Princeton Architectural Press, 2000.

Lynn, Greg. *Animate Form*. New York: Princeton Architectural Press, 1999.

Lynn,Greg. Multiplicitous and Inorganic Bodies. *Assemblage*, No:19 (1992): 32-49.
Rahim, Ali. "Systemic Delay: Breaking the Mold." *AD: Contemporary Processes in Architecture.* Academy Editions: London, Vol. 70 (2000): 6-8.

Schumacher, Patrick. "Rational in Retrospect : Reflections on the Logic of Rationality in Recent Design." in *AA Files* 38, Architectural Association (1999): 23-36.

van Berkel, Ben, and Carolione Bos. "The New, New Concept of the Architect-Revised, Recharged, Now More Hopeful Than Ever." *A+U* Vol. 405 (June 2004): 88-95.

van Berkel, Ben and Caroline Bos. *Korean Architects*, (November 1996).

Wigley, Mark and Catherine de Zegher (eds). *The Activist Drawing: Retracing Situationist Architectures from Constant's New Babylon to Beyond*. New York, Cambridge: MIT Press, 2001.

_____ "Diagrammatic Transformation of Architectural Space" *Philosophica,* Vol.70 (Ghent: Ghent University, 2002): 11-36.

_____"Interview: Ben Van Berkel." *Transitions* 57/58 (1997): 104-107.

APPENDIX A

AN INTERVIEW WITH BEN VAN BERKEL
September 2009

Başak Kuyumcu: I would like to suggest beginning with discussing the role of diagrams in your architectural design process. You introduced your design strategies as process-oriented with the introduction of diagrams as "proliferators." I think that it is important to reevaluate the design process with the conceptual ideas and its evolution through their embodiment and materialization in built form. In this respect, could you explain how your design process evolved from diagrams to construction?

Ben van Berkel: Yes. I have been always interested in process-oriented design strategies, because I think that for the concentration of architecture it is important to release architecture from a dependency on representational techniques. In the conventional design processes one starts with a sketch, and then continues with the architectural drawings and the introduction of the various parameters of the program. Finally one comes up with the construction of the building which is included the inclusive technical drawings. I think that is a very linear process and it is the reverse of our position. What I learned from other disciplines outside of architecture; such as the way scientists' experiment, how philosophers think, or from writers or movie makers, is that there are many different ways to tell a story or make a movie and this is also the case in architecture when developing techniques for making buildings. I have learned that you can start with the research of the material, how it can be enveloped or covered; or how people circulate on the location and this

analysis can be seen as movement studies that might add a particular kind of quality to the organization of a project. I concentrate on the relationships between information in the design process which are interactive, instrumental, structural, and virtual.

B.K: So you emphasize the importance of design of the design process as well. This way of designing would be significant to frame the design phases as well. Then, when are the diagrams introduced into the design? I wonder at which level the diagrams-as in your idea of Möbius strip for Möbius house- relate with the design process, at which stage the geometrical and spatial qualities are introduced?

BvB: If we refer to the Möbius House, the diagram is not introduced into the design process as if to say: We found a diagram, so let's make a house of it! What often happens is that the diagram is a tool which is used in the process, like in the phases of the Möbius House. In the case of the Möbius House, we first looked at the location and we had four *quadrum.* Therefore, we proposed placing a cross into the location because of the four different qualities of landscape. Then out of the cross we thought about how it can be linked together. So we came up with the idea of drawing a circle in the cross that can be twisted. That is one of the reasons that we come up with the Möbius strip idea. The idea was to have a cross movement going on the location where you move from- let's say one part of the landscape to the other or let's say one part of the house to the other. This idea of cross-structuring information applied to the construction of the house and the organization of the geometry. The program and the routing are also integrated by the diagram. So that living working and sleeping come together in the one coherent structure; in the Möbius Strip.

BK: Also it depends on the programmatic necessities, doesn't it?

BvB: Yes, exactly. It is also related to how diagrams can help to bring the information of the program together, which is important here in building the

diagram. A lot of people have the tendency to think that the diagram is a tool used in a linear way but that is not what I am interested in. My idea is the opposite of the representational technique of a linear process. You have to instrumentalize the diagram into an architectural spatial organization. And that does not have to be literal and linear.

BK: Actually as we refer to the Möbius House, it resemble the Möbius strip. As far as I read from the critics it is claimed that this spatial configuration of the Möbius strip is represented in the architectural construction of the house. Is the Möbius strip representational for your design? Do you have any concern to emphasize the diagram as representational?

BvB: No, I do not have any formal or literal concerns. The formal aspect of the Möbius Strip is instrumentalized. I think the most important aspect is how you work with diagrams not what the diagram is. The diagram is not representational but instrumental in the design process. It is not taken literally; it is transformed to provide possible relationships. Diagrams must be seen as proliferators, as tools to give you possible insight into the way you can use them for your design. But it is not important to take it formally or literally.

BK: We can say that you use the diagrams as proliferators in a process of unfolding a design process. It is conceptualized and abstracted in order to be able to be instrumentalized in the design process.

BvB: Yes. Diagrams can either be used as proliferators or as unfolding tools for the production of information. The instrumentalization of the diagram in the design process allows for a proliferating, generating and open system for the design process. For me the diagram cannot contain representational information and is not used as a metaphor.

BK: Which aspects of the diagram do you find proliferative? Do they inherit the

generative aspects themselves in order to define an architectural design process?

BvB: Yes, sometimes. Diagrams are generative in the way they work like a map, like an infrastructure. So, they could be seen as a possible way of defining an infrastructural organization of the building. It is not so much related to the materials, or how it can be seen as a structure in the first place. However, what is very interesting about mathematical, topologic structures like the Möbius Strip or the Klein Bottle is that they have geometrically self generating potentials. Because they have inclusive qualities; they could easily be reduced to the structural possibilities also; they can also be transformed for defining the spatial qualities. I used them also for Mercedes-Benz Museum. I also transformed the diagram as a Seifert Surface which is a very important mathematical surface and used it for the masterplan of Arnhem Central, and of course for the Möbius House.
So, it is very important how diagrams are used as an instrument for design. However, there are many types of diagrams besides the mathematical diagrams that can be used as structural and infrastructural instruments. I am trying to distinguish how to work with different diagrams.

BK: This is what you are emphasizing with the "design models"-defining various diagrams for constructing your design process. Isn't it?

BvB: Yes, exactly. We use various diagrams in our design processes. But what is important is how you use them, how you transform them to produce potential diversities. We want these models to completely unfold in our works. Unfolding, instead of reduction. Instead of finding a single, ideal, universally usable model I want to keep it operative and experimental. It should constantly continue to develop. There are a lot of ways to design a building, also with the introduction of computer programs. This indicates the complexity of the design process. "Design models" reduce this complexity and develop a disciplined way of working.

BK: What makes the "manimal"- a computer image of the hybridization of a lion, a snake and a human- a diagrammatic image to you as an architect?

BvB: Manimal is a very important image to me. Because it was for me the first time that I discovered that we can go beyond the collage. Even the whole modernist movement and after the post-modernist movement, and the arts for instance, have always worked with principles of the collage. The idea of the collage is a very old principle. But we could go beyond the collage without boundaries in the image. I thought that it was a very interesting to observe in the manimal that you cannot see exactly if it is real, or if this is the form of man or an animal. And also it works like the face, where you know that it has a coherent surface, the face without boundary. But in that coherency a lot of difference can be found; more difference than one can find in a collage. I thought that it was interesting that a lot of qualities of difference could be pointed out, but that recognition was difficult in the image. You are not aware where the man is, where the snake is or where the lion is exactly. You do not know what it is. And I found a double-reading of the manimal; first is the way it is organized without being a collage anymore, it is not fragmented. Second is the potential to create after-images that generate different meanings. That is why I find it very interesting. For me this is an example of inclusiveness and intensive coherence as an effect. There are no boundaries of the previous images in the new image. They come together to define a new organization. In architecture the manimal could be read as dissolution of several different structures, which start to generate a new notion of scale. A building should be organized in that way. Diagrams can be read as organizational aspects of the manimal that make new readings possible.

Also for me it is interesting in terms of how we could start to set off an argument around the digital coherence. I am interested in this aspect of the digital coherence, that the digital world can generate far more coherence than we think. With the aid of computer-supported design, we can radically evaluate the basic typologies that have

evolved in building history and work with new ingredients. We can combine a number of principles to achieve far more complex results. I see that as a positive aspect our culture today that we are growing much more together. This new digital technology creates more intensity and coherence. It is sometimes virtual, but the virtual in itself creates attraction. And I think this is also what is interesting about the manimal. It attracts you and it also shocks you. It seems like a negative image but this is exactly what the beauty of the image is. It is not about the beautiful, it is more about the quality of the intensity of the manimal.

APPENDIX B

CURRICULUM VITAE FOR UN STUDIO

UN Studio, founded in 1988 by Ben van Berkel and Caroline Bos, is a Dutch architectural design studio specializing in architecture, urban development and infrastructural projects in Amsterdam. The name, UN Studio, stands for "United Network Studio" referring to the collaborative nature of the practice, was given in 1998 after the name "van Berkel & Bos Architectuurbureau" which was used between 1988-1999. Collaboration between architects, graphic designers and constructors, building consultants, photographers, stylists and media designers form the organization of design strategies in the studio.

Over the last years several large international projects were awarded to the Studio and a number of prestigious competitions were won. As result UN Studio underwent rapid expansion to 115 employees at present. To ensure the quality of both the organization of UN Studio as a professional practice and its performance in the architectural field Gerard Loozekoot and Astrid Piber became partners at the beginning of 2008, joining Harm Wassink who has been a partner since 2006.

UN Studio works as a part of a united network. A highly flexible methodological approach has been developed which incorporates parametric designing and collaborations with leading specialists in other disciplines. Drawing on the knowledge found in related fields facilitates the exploration of comprehensive strategies which combine programmatic requirements, construction and movement studies into an integrated design. With this network approach UN Studio can set-up

multidisciplinary teams from early stages onwards in order to create an efficient and integrated working process.

In April 2010 UN Studio opened the 'UN Studio Asia' office located in Shanghai, China. UN Studio Asia is connected to UN Studio Amsterdam. The new Shanghai office serves in the first instance to facilitate the design process for the Raffles City project in Hangzhou - currently in the design development stage.

Ben van Berkel - Principal Architect

Co-founder of the studio and the principle architect, Ben van Berkel, studied architecture at the Rietveld Academy in Amsterdam and at the Architectural Association in London, receiving the AA Diploma with Honours in 1987. He taught also in AA, in Columbia University, in Berlage Institute, and in UCLA; he has been a visiting lecturer at Princeton University, and he is currently professor of Conceptual Design and head of the architecture department at the Staedelschule in Frankfurt am Main, Germany.

His first projects were built almost immediately after founding Van Berkel & Bos Architectuur Bureau. Among the buildings of this first period are Karbouw, the Remu electricity station, and Villa Wilbrink. Being elected to design the Erasmus Bridge in Rotterdam (1996) profoundly affected his understanding of the role of the architect today and constituted the foundation of his collaborative approach to practising, leading to the foundation of UN Studio in 1999.

In the blue period as they called resulted in the realization of projects such as The Möbius House, Het Valkhof Museum (1998), and the Prince Claus Bridge (2003). Recent projects, which reflect his longstanding interest in the integration of construction and architecture, are: the Mercedes-Benz Museum in Stuttgart and Arnhem Central.

Caroline Bos - Principal Urban Planner

Caroline Bos, who is also a visiting lecturer at Princeton University and has taught at the Berlage Institute, and UCLA, is the other co-founder and the principal urban planner of the studio. She studied History of Art at Birkbeck College of the University of London. After co-founding Van Berkel& Bos Architectuur Bureau in 1988 she stopped working as journalist to focus on being the internal critic for the practice, writing everything from employment contracts to essays and descriptions of projects that were yet to be designed. In 1999 Ben van Berkel and Caroline Bos founded UN Studio. As an analyst she has been involved in all UN Studio projects. Her observations and synthesis on different programmatic issues has become integral with the work of the different project teams.

With Ben van Berkel she was editor of Forum (1985-86) and the ANY publication 'Diagram Works' (1998). Her interest in the concept of the architect is reflected in the books she has co-written with Ben Van Berkel: 'Ben van Berkel Architect' (1992), 'Delinquent Visionaries' (1990), 'Mobile Forces' (1994), 'Move' (1999), Unfold (2003), 'Design Models' (2006). Bos recently completed a Master's Degree in urban and regional planning, at the Geosciences Faculty of the University of Utrecht.

PUBLICATIONS

Reflections - Small Stuff by UN Studio (Ideabooks, 2010).

Buy me a Mercedes Benz-The Book of the Museum (Actar, December 2006).

UN Studio: Design Models - Architecture, Urbanism, Infrastructure (Rizzoli, 2006).

Love it, Live it - Ben van Berkel, Design Document Series (DD) (Damdi Arch. Publishing, 2003).

UN Studio: Unfold (Rotterdam: NAi Publishers, 2002).

Move, 3 vol. (Amsterdam: UN Studio & Goose Press, 1999).
Museum Het Walkhof (Amsterdam, 1999).
Mobile Forces-Mobile Kräfte. (Berlin: Ernst & Sohn, 1994).
Delinquent Visionaries, a collection of essays (Rotterdam, 1993).
Ben van Berkel monograph (Rotterdam, 1992).

Information compiled from:

UN Studio, http://www.unstudio.com. Last accessed in August 2010.
Ben van Berkel and Caroline Bos, Move *1-2-3* (UN Studio & Goose Press, 1999).
Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006).

APPENDIX C

PROJECT CREDITS

Möbius House
Het Gooi, Netherlands 1993-1998

Möbius House awarded 1999 Dutch Concrete Award.

Client: Anonymous
Program: Single-family house
Gross Floor surface: 520 m^2
Volume: 2,250 m^3
Site: 20,000 m^2
Design Team: Ben van Berkel(architect), Aad Krom (project management), Jen Alkema, Matthias Blass, Caroline Bos, Remco Bruggink, Mark Dijkman

Interior Design: Ben van Berkel, Hans Kuyvenhoven, Jen Alkema, Matthias Blass
Lanscape Design: Adriaan Geuze, West 8 Landscape architects, Rotterdam
Technical consultants: ABT, Velp, Heijckmann Bouwadviesbureau, Huissen
Building contractor: Kemmeren Bouw, Aalsmeer
Interior contractor: Meubel & Interierbouw Wageningen BV

Arnhem Central Station
Arnhem, Netherlands, 1996-

Arnhem Parking garage awarded 2005 ANWB Award
Client: Municipality of Arnhem
Programme: masterplan, transfer hall, underground parking, bus terminal, two office towers, bicycle storage, railway platforms
Building area: transfer hall 6,000 m^2/ underground parking 44,000 m^2/ bus terminal 7,500 m^2/ two office towers 22.000 m^2 /capacity 110,000 transfers per day

Design: UNStudio in collaboration with Cecil Balmond (Arup)
UNStudio: Ben van Berkel with Tobias Wallisser and Sibo de Man
Masterplan study: Ben van Berkel, Freek Loos, Peter Trummer, Henk Bultstra, Cees Gajentaan, John Rebel, Andreas Krause
Masterplan: Sibo de Man, Tobias Wallisser, Henk Bultstra, Edgar Bosman, Astrid Piber, Oliver Bormann, Yuko Tokunaga, Ulrike Bahr, Ivan Hernandez
Transfer Hall: Tobias Wallisser with Arjan Dingsté, Nuno Almeida and Marc Herschel, Rein Werkhoven, Matthew Johnston, Sander Versluis, Misja van Veen, Derrick Diporedjo, Marc Hoppermann, Ahmed El-Shafei, Daniel Gebreiter, Uli Horner, Freddy Koelemeijer, Wouter Hilhorst, Maartje van Dehn, Kirstin Sandner, Elisabeth Beusker
Engineering: Arup, Amsterdam
Structure: Van der Werf & Lankhort, Arnhem

Mercedes-Benz Museum
Stuttgart, Germany 2001-2006

Mecedes-Benz Museum awarded Concrete Architecture Award 2008, Architekturpreis Beton 2008, German Design Prize 2008 for exhibition spaces, Nominee Mies van der Rohe Award 2007, and Ingenieurbau Preis 2006.

Client: DaimlerChrysler AG, **Builder/owner:** DaimlerChrysler Immobilien, Berlin
Program: Car museum, shop, restaurant, offices, auditorium
Gross floor surface: 35.000 m^2
Volume: 210,000 m^3
Site: 285,500 m^2
Number of Vehicles exhibited: 160

Design Team: Ben van Berkel, Caroline Bos and Tobias Wallisser with Marco Hemmerling, Hannes Pfau
Exhibition concept and design: Prof. H.G. Merz, Stuttgart
Interior Architecture: UNStudio with concrete architectural associates, Amsterdam
Structure: Werner Sobek Ingenieure with Bol & Partner, Stuttgart
Geometry: Arnold Walz, Stuttgart
Climate engineering: Transsolar Energietechnik, Stuttgart
Costing: Nanna Fütterer, Stuttgart/Berlin
Project Management: Dress & Sommer, Stuttgart
Infrastructure: David Johnston, Arup, London

Information compiled from:
UN Studio, http://www.unstudio.com. Last accessed in August 2010.
Ben van Berkel and Caroline Bos, *Buy me a Mercedes Benz-The Book of the Museum* (Actar, December 2006).
Ben van Berkel and Caroline Bos, Move *1-2-3* (UN Studio & Goose Press, 1999).
Ben van Berkel and Caroline Bos, *UN Studio: Design Models - Architecture, Urbanism, Infrastructure* (Rizzoli, 2006).

APPENDIX D

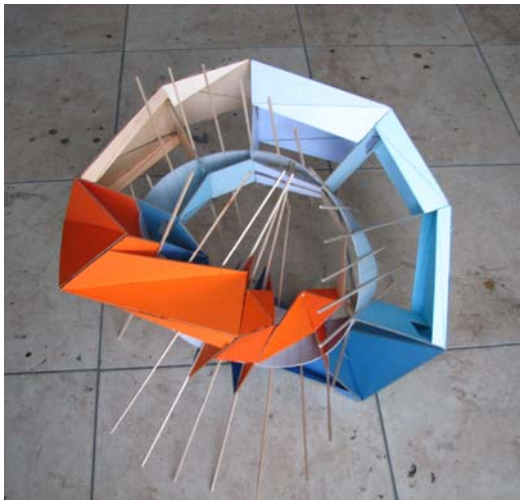
ARCH 101 BASIC DESIGN FINAL PROJECTS

METU Fall' 09

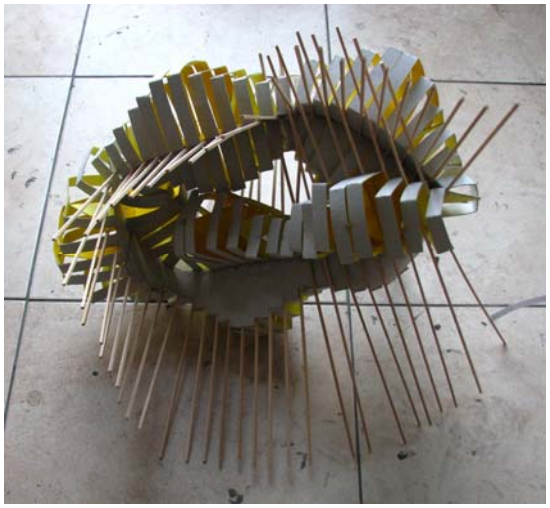
A 3-D Design Based on the Möbius Concept:

A "habitat" for an Automaton

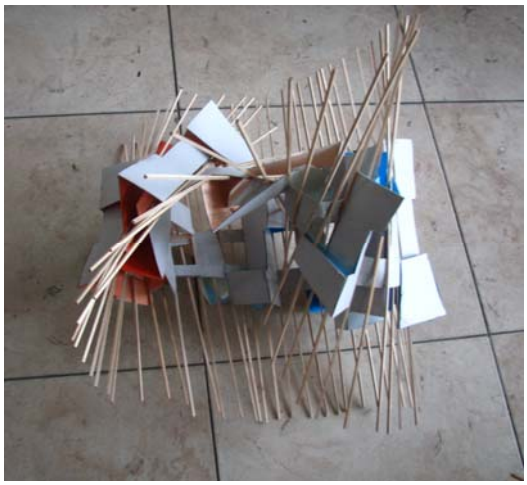
Photos by İlkay Dinç



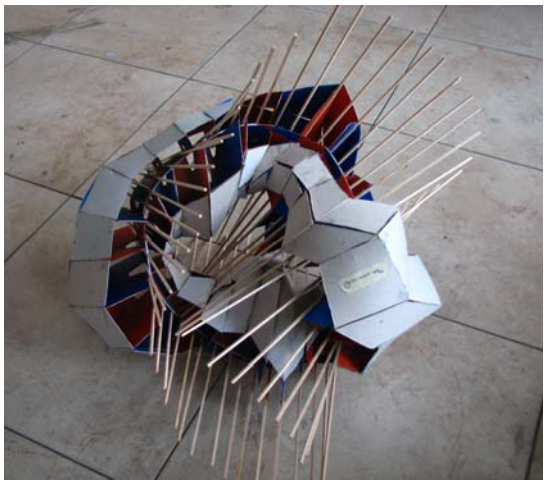
Farzad Golghasemi



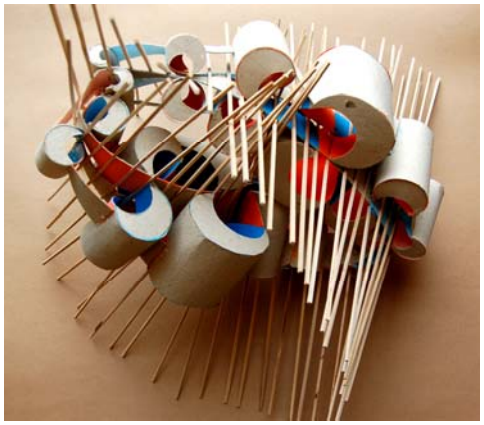
Derya Güngör



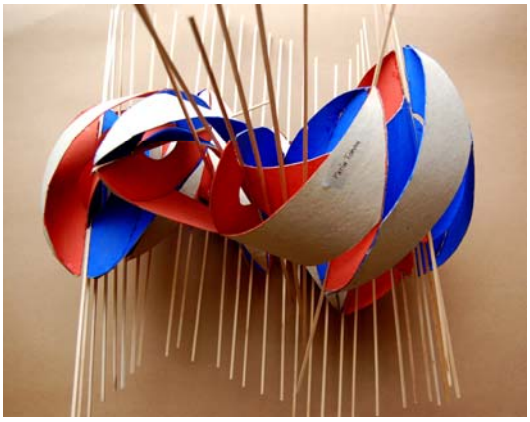
Elif Düzel



Seyit Ahmet Dal



Burak İlhan



Fatih Topak